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NINETEENTH ANNUAL REPORT

of

Pasture Research

in the

Northeastern United States
State College, Pennsylvania

1955



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1955

Nineteenth Annual Report
of
Pasture Research
in the
Northeastern United States

U. S. Regional Pasture Research Laboratory
State College, Pennsylvania
Forage Crops and Diseases Section
Field Crops Research Branch
and
Eastern Section of Soil and Water Management
Soil and Water Conservation Research Branch
Agricultural Research Service
of the
U. S. Department of Agriculture
and
The Agricultural Experiment Stations
of the
Twelve Northeastern States
Cooperating

- - - - -

Copies of this report were sent to all organizations involved in the development of the present pasture research program in the twelve Northeastern States and in addition to some institutions outside the Region where grassland research is a major interest.

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B.

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TABLE OF CONTENTS

Research at the Pasture Laboratory

	Page
Introduction	1
Genetics and pathology	2
Alfalfa	2
Inheritance of clones and their S_1 's	2
Progenies of rhizomatous and upright	3
Selection for disease resistance	3
Ladino clover	4
Self-compatible	4
Recombination of characters	4
Selection for persistence at low light intensity	4
Selection for resistance to <u>Sclerotinia trifoliorum</u>	5
Damping-off of legumes	5
Red clover	6
Root rot complex	6
Inoculation techniques with <u>Sclerotinia trifoliorum</u>	6
Meadow fescue and perennial ryegrass	6
Intergeneric hybridization	6
Crown rust immunity in <u>Festuca elatior</u>	8
Bromegrass	8
Selection for increased seedling vigor in <u>Bromus inermis</u>	8
Interspecific hybridization in Bromus	8
Hexaploid B. <u>inermis</u>	10
Reaction of B. <u>inermis</u> to <u>Pyrenophora bromi</u>	10
Orchardgrass	11
Selection for resistance to foliar diseases	11
Dying-out	12
Reed canarygrass	12
Progenies of 35-chromosome <u>Phalaris arundinacea</u>	12
Phalaris interspecific hybrids	13
Brown stripe of grasses	13
Helminthosporia on grasses	14
Biochemistry, physiology and soils	15
Physiological studies of <u>Sclerotinia trifoliorum</u>	15
Carbohydrate studies on grasses	16
Measurement of nutritive value of pasture plants	17
Atmospheric moisture in the microclimate	18
Plant climate: Comparison of plant and air temperatures	18
Soil temperatures under a Kentucky bluegrass sod	18

Legume seedling establishment	19
Cutting practices and effects on alfalfa	20
Role of hard seed of Ladino clover in natural reseeding	20
Responses of grasses vs. legumes to phosphorus and potassium fertilization	21
Fertilizer placement for perennial forage crops	21
Response of perennial forage crops to irrigation	22
Soil compaction in permanent pastures	23

Reports of Cooperative Projects

Project NE-13 - The mechanization of forage crop harvesting, processing, storing and feeding	24
Project NE-18 - Economics of forage production and utilization	26
Project NE-24 - The nutritive evaluation of forages	28
Project NE-28 - Breeding and evaluation of improved varieties of forage crops adapted to the Northeast	30
Project NE-29 - Establishment and management of perennial forage species and varieties for persistent production in the Northeast	32

Pasture Research at State Stations

Connecticut (Storrs)

Alfalfa experiments	35
Fertilization	35
Varieties	35
Management	36
Maintenance and improvement of pastures	36
Ladino clover fertilization	36
Sudangrass varieties	38
Use of herbicides in forage crop management	38
Control of grasses in alfalfa stands	38
Use of chemicals for pasture renovation	38
Effects of fertilization on the prevalence of white and red clovers in permanent grassland	39
Penetration of topdressed limestone into soil of untilled grassland	40

Maine

Breeding and evaluation of forage crops	41
Forage production of nitrogen-fertilized grasses and legume-grass mixtures	41
Molybdenum fertilization of alfalfa	42
Grass silage preservation	42

F.

Maryland

Variety testing, alfalfa, red clover, orchardgrass and tall fescue, Sudangrass and pearl millet, Bermudagrass	43
Evaluation of grass for use with alfalfa for hay	44
Ladino clover breeding	44
Improvement of red clover	45
Orchardgrass breeding	45
Tall fescue management	46
Nitrogen fertilization on grass and grass-legume associations	46
Fertilization of bluegrass pastures	47
Grass and legume combinations for beef production	47

New Hampshire

Breeding of smooth brome grass, Ladino and red clover	48
Water and fertilizer requirements as related to irrigation	49
Available potash and persistence of Ladino clover in hay stands . . .	50
Effects of fertilization on mineral content of forage and of feeding such forages to dairy cattle	50
Maximum use of silage in feeding dairy cattle	51
Preservatives and carotene content	51
Soil type and mineral additions vs. mineral content of timothy and clover	52
Cooperative regional research on white clover (Ladino)	52

New Jersey

Breeding productive wilt resistant alfalfa	53
High N and K fertilization of alfalfa	54
Effect of plant food combinations on alfalfa	54
Effect of time of fertilizing alfalfa	55
Effect of plant food combinations on birdsfoot trefoil	56
Effect of time of fertilizing birdsfoot trefoil	56
Pasture renovation studies	57
Horse pasture research	58
Preservation of forages in plastic materials	60

New York (Cornell University)

Breeding and cytogenetic investigations with the forage plants of New York	60
Evaluation of forage crops varieties and strains for use and adaptation in the northeast	62
Strain testing and breeding of forage plants and production during midsummer drought	65
Birdsfoot trefoil culture and management for hay, pasture and silage	67
Birdsfoot trefoil seed production	68
Birdsfoot trefoil evaluation, improvement and breeding	68
Factors affecting seeding establishment of forage plants	69
Effect of stage growth upon yield, nutritional value and longevity of principal forage grasses and legumes	69

Birdsfoot trefoil investigations	70
Diseases of forage crops	70
Effects of wilting and chopped hay on storage losses and value of silage	71
European chafer investigations	71
Insects and birdsfoot trefoil	72
Alfalfa snout beetle	73
Clover root borer	73
<u>Pennsylvania</u>	
Genetics and improvement of alfalfa	75
Genetics and improvement of red clover	75
Genetics and improvement of birdsfoot trefoil	76
Genetics and improvement of forage grasses	76
Alfalfa crown rot	78
Forage production of rye and annual winter grasses	78
Grazing new strains of legumes and grasses in mixtures	79
Renovation of unproductive pastures	79
Methods of preservation and nutritive values of forage	80
Forage insects	81
Feeding grass silage to dairy calves	83
<u>Rhode Island</u>	
Breeding improved alfalfa	84
Soil fertility and moisture relations	84
Potash sources and ratios	85
Foliar diseases of alfalfa and control with fungicides	85
Insect and allied pests and control	86
Zero pasture feeding of dairy cattle	86
Grass-legume silage as sole roughage for dairy cattle	87
Poultry range studies	88
<u>Vermont</u>	
Simulated pasture management and persistence, quality and yield of birdsfoot trefoil	89
Trefoil variety trials	89
Ladino clover yield trials	90
<u>West Virginia</u>	
Alfalfa breeding and genetic investigations	90
Use of nitrogen on bluegrass	91
Alfalfa varieties	92
Fertility and management as affecting several Ladino clover- grass mixtures	92
List of publications	94

PASTURE RESEARCH IN THE NORTHEASTERN UNITED STATES

This report, the nineteenth in the series, was prepared by, and is intended primarily for the use of, personnel engaged in forage crop research in the twelve Northeastern States. It contains a brief summary of progress in the Region during 1955. Included are activities at the Pasture Laboratory, at each of the state experiment stations and of the various forage crop technical committees. The respective Chairmen of these committees submitted reports on the regional projects, the Collaborators were responsible for assembling and editing material from their respective stations and the project leaders at the Pasture Laboratory prepared the descriptions of their research. For the first time regional reports are included of NE-13 (mechanization) and NE-18 (economics of forage crops).

Two full-time assistants were added to the Laboratory Staff during the year, Charles F. Gross in soils and Jack E. Field in biochemistry. Mr. Field received his training in chemistry at The Pennsylvania State University and Mr. Gross has a Master's degree in agronomy from the University of Rhode Island. G. H. Elkan, part-time assistant in soils, completed his graduate work for the Master's degree and is now employed part-time with the Virginia Agricultural Experiment Station and continuing his graduate work.

Dr. T. S. Ronningen was appointed Collaborator to take the place of Dr. A. O. Kuhn now Assistant to the President of the University of Maryland. Dr. R. P. Murphy, Head of the Department of Plant Breeding at Cornell University and a Collaborator with the Forage and Range Section, U.S.D.A., has also assumed the duties of Collaborator with the Pasture Laboratory replacing Dr. S. S. Atwood. Dr. Atwood who was formerly one of the Project Leaders at the Pasture Laboratory has recently been made Provost of Cornell University.

The Collaborators did not hold a conference during 1955 but the technical committees met as usual. The activities of the technical committee formerly designated as NE-21 became so broad that it was decided to set up three committees to take over and in some cases expand certain phases of the old project. The new committees were designated as NE-24 (nutritive evaluation of forage crops), NE-28 (breeding), and NE-29 (management and seedling establishment). These three committees are scheduled to meet simultaneously during January 19 and 20, 1956 in New York City. At least one joint session is planned.

RESEARCH AT THE PASTURE LABORATORY

GENETICS AND PATHOLOGYAlfalfaInheritance of Flower Color in Medicago sativa

An investigation to determine the effect of a change in soil pH on alfalfa flower color has been carried out in conjunction with flower color inheritance studies. Lime or aluminum sulfate was added to soil surrounding plants of 20 clones prior to blooming. These clones represented a range in color from light to dark purple. Treated plants did not differ from the checks in color although some treatments were severe enough to produce necrotic areas in the plant tissue.

Purple segregates from a purple x white cross were selfed and the resulting progeny were classified for flower color in the field. The plants were compared with the parental purple where this was possible. The original cross was presumed to have been simplex x nulliplex. A number of the plants deviated significantly from the 3:1 ratio expected with random chromosome segregation. Additional progenies will be grown from selfed seed to determine if these plants might be showing random chromatid segregation.

Yields of Alfalfa Clones and Their Inbreds

Green weight yields of individual plants were taken at two harvests in the planting of clones and S_1 's previously described (1954 Annual Report, page 3). For the test which includes 25 clones and their S_1 's, the average yields of the S_1 's for the first and second harvests, respectively, were 64.6% and 66.9% of those of the clones. The highly significant interaction, generations x families, at both harvests indicates that the reduction in vigor following selfing was relatively greater for some clones than for others. The correlation between yield per plant of clones vs. mean yield per plant of S_1 's for the 25 entries is +.27, +.31 and +.26 respectively for first cut, second cut and season total yield.

A number of S_1 plants yielded more than the parent clones. Twenty-three of these S_1 's were selected for further comparison of vigor with their respective parents in replicated plantings.

Comparison of Progenies of Rhizomatous and Upright Alfalfa Selections

This planting (1953 Annual Report, page 3) was harvested for the second year. Stand counts were taken in June and October. Polycrosses differed significantly in number of plants killed, but these differences were not associated with upright or spreading habit. In June there had been a greater stand depletion in the plots managed to simulate grazing than for plots managed for hay. By October, the difference in stand due to management was greater and significant. The interaction, managements x strains, for the stand data was not significant. The correlation between stand survival of 18 strains under hay vs. simulated pasture management was $+0.53^*$. Many plants, particularly in the plots managed to simulate grazing, appeared weakened and it is expected that another year will bring about more serious stand depletion.

In analysis of the yield data for 1955, both the alfalfa fraction and alfalfa plus associated S-37 orchardgrass showed significance at the 1% point for strains, managements (hay vs. simulated pasture), strains x managements, cuts (1st vs. total aftermath), cuts x strains, and cuts x managements. The second order interaction, CxSxM, was significant for the alfalfa fraction only.

Alfalfa fractions of the yields on plots managed to simulate grazing (4 cuts) were 27, 76, and 57% of the yield of the same strains managed for hay at the first cut, aftermath cuts, and season total, respectively. Comparable values for the alfalfa plus orchardgrass yields were 46, 88, and 70%, indicating that the orchardgrass yielded more on plots harvested more frequently. This series of plots will be harvested at least one more year.

Selection for Disease Resistance in Alfalfa

Crosses were made between Vernal and selections with resistance to Pseudopeziza medicaginis and Ascochyta imperfecta and between Pasture Laboratory clones and selections with resistance to the above mentioned leaf diseases, (1954 Annual Report, page 3). The F_1 populations were established in the field with every fifth row planted to Buffalo or Vernal. Freshly cut alfalfa infected with the two disease organisms was scattered over this planting at periodic intervals during the summer and fall. Satisfactory infection was obtained and approximately 2% of the F_1 population representing materials of diverse origin was selected. The selections are being backcrossed to Vernal and Laboratory clones, and the first backcross generation will be established in the field in 1956.

Several of the more desirable appearing F_1 's are also being intercrossed to produce F_2 populations.

Ladino Clover

Self-compatible Ladino Clover

Self-compatible lines have been crossed with clones possessing various leaf markings for further study of the inheritance of these characters. Several S_1 populations have segregated for normal chlorophyll development vs. albinism in ratios of 9:7, 3:1, and 57:7 which indicate that at least three factor pairs, two of which are complementary, condition normal chlorophyll development in Ladino. One plant gave a segregation of 27:37 indicating three complementary factors.

It is anticipated that lines homozygous for red leaf marking will be used in two ways, namely, as markers in attempts to isolate polyhaploid plants of Ladino and to study the extent to which non-random pollination occurs in a polycross nursery.

Recombination of Characters in Trifolium repens

Seed of six single crosses and their F_2 's was used to establish replicated plots for a comparison of the two generations.

Selection for Persistence at Low Light Intensity

The clones selected for a synthetic were reduced to 5 (53-93, 53-101, 53-102, 53-107, and 53-110) and established in the field to produce synthetic seed under a cage. Flowering was sparse in 1955 but seed for limited testing should be produced in 1956.

Single crosses among these and additional clones will be used to establish a new source nursery in 1956.

Polycrosses of the 5 above clones, polycrosses of 5 other clones selected for persistence at low light intensity, but which are less field persistent, plus polycrosses of 5 field persistent clones selected for resistance to Sclerotinia, and polycrosses of 5 Sclerotinia-resistant-clones with less field persistence have been established in glazed pots and are being grown at low light intensity. This will afford an opportunity to evaluate the progress from selection at low light intensity and determine whether persistence of polycrosses at low light intensity is related to field persistence of the same polycrosses or their parental clones.

Polycrosses of 19 clones with good field persistence were established in field plots along with polycrosses of clones selected for resistance to Sclerotinia and check varieties.

Selection for Resistance to Sclerotinia trifoliorum

The clones of this material selected for a synthetic were reduced to 5 on the basis of data supplied by Maryland, Minnesota and New Hampshire. These clones (53-27, 53-29, 53-36, 53-40 and 53-78) were established under a cage and are expected to produce seed in 1956.

Polycrosses of 34 of the clones originally selected for resistance to *Sclerotinia* that showed better than average field persistence were established in a test with polycrosses of clones selected for persistence at low light intensity. Six replications were seeded, two with brome grass, two with orchardgrass, and two in which one-half of the plot was seeded with orchardgrass and the other one-half to Ladino alone. The latter two replications were inoculated with *Sclerotinia*. The persistence of the strains will be evaluated under these varied environments. This experiment provides an opportunity to detect any influence that the associated orchardgrass may have on development of *Sclerotinia* on Ladino.

Single crosses among more promising clones will be used to establish a new cycle of breeding material.

Damping-off of Legumes

A series of experiments was conducted to determine the pre-emergence and postemergence damping-off of Ladino clover and Lespedeza by *Fusarium roseum*, *Pythium debaryanum*, and *Rhizoctonia solani* at 7 temperatures and 3 levels of soil moisture. The most favorable temperatures for mycelial growth of both *Fusarium* and *Rhizoctonia* were 66-80°F. and of *Pythium*, 66-87°F. Optimum temperatures for most rapid seedling emergence of Ladino clover were 66-73°F. and of Lespedeza 80-94°F. Analysis of variance showed highly significant interactions among the various factors studied. In general, most pre-emergence damping-off of clover by the 3 fungi occurred at 80-94°F. and most postemergence damping-off at 59-73°F. With Lespedeza, pre-emergence damping-off was moderate at 52-66°F. Postemergence damping-off by *Rhizoctonia* and *Pythium* was very severe at 59-87°F., whereas *Fusarium* was active at 52-66°F. For both host species, *Fusarium* was most active in moderately dry soil and *Pythium* in wet soil (near saturation); *Rhizoctonia* was little affected by soil moisture.

Red Clover

Root Rot Complex of Red Clover

Survivors of the plants which were established in the field in Spring, 1954 (1954 Annual Report, page 5) will be dug in Spring, 1956 and the roots rated for disease and root borer damage. Open-pollinated seed from these will be used to establish a nursery for a new cycle of selection.

Inoculation Techniques with Sclerotinia trifoliorum

Incident to selecting for resistance, field tests were conducted for two years to determine the best time of year for inoculation of red clover with Sclerotinia trifoliorum (1954 Annual Report, page 5). Spring and summer seeded plots were inoculated with dried grain inoculum at 15-day intervals from August to April. Maximum killing of plants (85-95%) occurred when the inoculum was applied October 1 and 15. Very few plants were killed when inoculated before August and after December 15. The data indicate that a few weeks of cool weather with adequate moisture are necessary for the build up of the fungus to epidemic proportions.

Meadow Fescue and Perennial Ryegrass

Intergeneric Hybridization

No seed was obtained from attempts in the greenhouse to cross the hexaploid derivatives of (Lolium perenne 2n x Festuca elatior 4n) with Festuca arundinacea. The induced hexaploids and tall fescue have been planted together in the field where it is hoped that natural crossing may occur.

Approximately 1600 open-pollination progenies of the triploid intergeneric hybrids were established in the field in 1955. The triploid plants which produced seed had not been isolated from perennial ryegrass, meadow fescue or tall meadow fescue. Their progenies theoretically could have resulted either from the functioning of pollen produced by the triploids or from pollen from the above species.

The 1600 plants were observed during the growing season and a diversity of types was noted. Some of the plants resembled one or the other of the original parent species, whereas some resembled the triploid mother plants. Additional plants exhibited definite characteristics of tall fescue, i.e. coarser foliage and hairy auricle. A few plants were obtained which, on the basis of vegetative characteristics might be classified as Festuca ovina.

One hundred and eighteen plants representing the several phenotypes were studied to determine chromosome numbers with the following results:

Phenotype	Plants with Chromosome Numbers			
	<u>14</u>	<u>21</u>	<u>28</u>	<u>35</u>
Coarse (T.F. like)	0	0	5	18
Fine (like <u>F. ovina</u>)	0	10	0	0
Medium fine (like <u>L. perenne</u>)	0	11	0	0
Coarse	0	4	2	0
Extreme vigor (like <u>F₁</u> hybrid)	0	66	3	0

The three plants with 28 chromosomes in the phenotypic class resembling the F₁ hybrid were of particular interest as they may represent the amphidiploid of Lolium perenne and diploid F. elatior. These three plants were re-examined and an attempt was made to select plants from the remaining plants in the nursery that would duplicate this phenotype. From 30 such selections, it was found that 7 possessed $2n = 14$, 22 were $2n = 21$, and one possessed 28 chromosomes. Of interest is the absence of any diploid plants among the 118 plants in the first sample; while 7 of 30 of the latter sample were diploids. Possibly these 14-chromosome plants may represent the undoubled equivalent of the 28-chromosome plants presumed to be amphidiploids.

The 28-chromosome plants probably offer the greatest opportunity for selection for sexual fertility. Meiotic studies will be conducted on plants in the various chromosome number categories and selections for fertility will be made in 1956.

The appearance of progenies with 14, 21, or 28 chromosomes suggests that the functional female gametes of the triploid parent possessed either 7 or 14 chromosomes. The 28- and 35-chromosome plants which received 21 chromosomes from tall fescue add support to this conclusion.

Plants with 35 chromosomes, i.e. (L. perenne $2n$ X F. elatior $4n$) x F. arundinacea possess the cytoplasm from perennial ryegrass and the haploid set of chromosomes from each of the three species involved in the parentage. These polyhaploids are less vigorous than the triploid parent or tall fescue. If doubled and intercrossed, however, an increase in vigor comparable to that experienced from intercrossing inbreds of other crops might be expected.

The 35-chromosome plants have been treated with colchicine in an attempt to induce fertility.

The hexaploids obtained by treating the original triploid hybrids with colchicine were permitted to interpollinate in 1955. Fertility in these is very low but a few hexaploid seedling derivatives have been obtained so that selection for fertility can be continued.

Limited meiotic studies on the colchicine derived hexaploids indicate that there is possibly a higher frequency of micronuclei per quartet in them than in their triploid progenitors. This phase of the study has been hampered by the fact that much of the material collected for cytological study was mixoploid. The hexaploid seedlings now available should permit a more critical evaluation of the meiotic behavior at the hexaploid level.

Crown Rust Immunity in Diploid Festuca elatior

Restricted polycross seed was harvested from three clones of meadow fescue with immunity to crown rust. This seed is available for limited testing either from the Pasture Laboratory or from A. A. Hanson at Beltsville.

Bromegrass

Selection for Increased Seedling Vigor in Bromus inermis

Polycrosses of 30 clones with greatest seedling vigor and of 30 clones with least seedling vigor from a group of 120 clones tested in the greenhouse were planted in the field at a depth of 1-1/2 inches. Emergence in the field was correlated very poorly with emergence in the greenhouse. The polycrosses of the group rated best in the greenhouse averaged 4.6% greater emergence in the field test than the group which gave poorer results in the greenhouse. In this test, where the seed was harvested a uniform number of days following anthesis, all lots gave fairly satisfactory emergence at a planting depth of 1-1/2 inches except a few polycrosses having seed weight distinctly below average.

Interspecific Hybridization in Bromus

Studies on the meiotic pairing relationships of the triploid hybrids were continued. The frequency of trivalents was found to be somewhat higher than preliminary observations had indicated, averaging about 1 per P.M.C. The frequency of bivalents averaged less than 6 per P.M.C. with the balance of the chromosomes existing as univalents.

From new hybridizations which were attempted, hybrids were obtained from the following crosses: B. anomalus ($2n = 14$) X B. grandis ($2n=14$), B. grandis X B. laevipes ($2n = 14$), B. laevipes X B. grandis, B. frondosus ($2n = 28$) X B. ciliatus ($2n = 28$), and B. ciliatus X B. frondosus. The cross C-2 X B. frondosus produced one seed which germinated but failed to survive beyond the early seedling stage. C-2 represents an unidentified species from Colorado. It possesses certain characteristics of both B. richardsonii and B. ciliatus. The crosses B. laevipes X B. inermis ($2n = 56$), and B. tomentellus ($2n = 28$) X B. inermis ($2n = 56$) produced seeds which failed to germinate.

The cross B. ciliatus X B. frondosus and its reciprocal each produced two distinct types of hybrids, one being normal in its growth habit and the other being definitely dwarfed. Meiotic studies of the "normal" hybrids revealed that they were tetraploids with $2n = 28$. The frequency of bivalents in metaphase I cells of these plants averaged greater than 12 with the remainder of the chromosomes existing as univalents, trivalents, and quadrivalents. The dwarf hybrids have so far failed to produce root tips suitable for chromosome number determination and have not yet headed.

The "normal" ciliatus-frondosus hybrids exhibited low fertility, and 4 F_2 seedlings have been obtained from them through open-pollination. These seedlings are currently being observed for evidence of segregation for characters which distinguish the parent species. It is hoped that these observations will provide information regarding the nature of the chromosome pairing in the F_1 hybrids.

Work on the colchicine-treated triploid material was continued. Doubled panicles ($2n = 42$) have been obtained from the B. anomalus X B. ciliatus and B. orcuttianus X B. frondosus hybrids and the meiotic pairing relationships of these amphiploid materials have been investigated. Doubled metaphase I cells showed an average frequency of approximately 18 bivalents with the remainder of the chromosomes occurring as univalents, trivalents, and quadrivalents.

Seedlings have been obtained from colchicine-treated material of the C-2 X B. grandis and B. anomalus X B. ciliatus hybrids. Those produced by the C-2 X B. grandis hybrid are remarkably uniform, and under greenhouse conditions, exhibit considerable vigor. Three of these seedlings examined for chromosome number were found to possess 42, or approximately 42, chromosomes. The seedlings produced by the doubled B. anomalus X B. ciliatus hybrid are less uniform and somewhat less vigorous.

Hexaploid Bromus inermis

Hexaploid plants obtained by allowing B. inermis ($2n = 28$) to be pollinated by B. inermis ($2n = 56$) were examined cytologically. All hexaploids exhibited a high frequency of laggards (up to 14) at metaphase I and a correspondingly high frequency of micronuclei in the quartets. Apparently the 14 chromosomes contributed by the tetraploid either failed to pair regularly with those contributed by the octoploid parent or there was pairing between 14 chromosomes supplied by each parent.

Of particular interest are two plants (with 56 chromosomes) from this cross. In contrast to the extreme irregularity of the hexaploids, these octoploid plants were very regular, in fact, more regular than is typical of normal octoploid B. inermis. The average number of univalents at metaphase I, laggards at anaphase I, and micronuclei per quartet for these plants was 0.21, 0.12, and 0.12, respectively. Chromosomes paired as bivalents at metaphase. It seems likely that these octoploids arose as a result of the fertilization of an unreduced egg from the tetraploid by a normally reduced pollen grain from octoploid B. inermis.

The orderly pairing of the chromosomes in the two octoploid plants suggests that B. inermis probably has two basic genomes represented in quadruplicate. The chromosomes in the 28 chromosome clone had presumably become sufficiently differentiated structurally to prevent normal synapsis with those contributed by the normal B. inermis. In the two octoploid plants obtained, the regular meiotic behavior then is probably a result of pairing between chromosomes (14II) contributed by the tetraploid and a similar condition for the reduced number of chromosomes contributed by the octoploid parent.

Chromosome counts in these plants were interpreted as showing that all of the gametes contributed by normal B. inermis possessed 28 chromosomes, thus indicating that if aneuploid pollen grains were produced they did not function on the tetraploid female parent.

Reaction of Bromus inermis to Pyrenophora bromi

Thirty-six clones classified in the field (25 resistant, 6 intermediate, and 5 susceptible) and their inbred and polycross progenies were inoculated in the greenhouse with the brown spot organism. The most

resistant progenies were selected. The following correlations were calculated from the data:

	<u>n</u>	<u>r</u>
Clones (greenhouse vs. field reaction)	36	+ .33*
Polycrosses (greenhouse) vs. Clones (field)	36	+ .41*
Polycrosses (greenhouse) vs. Clones (greenhouse)	36	+ .54**
S ₁ 's (greenhouse) vs. Polycrosses (greenhouse)	31	+ .42*
S ₁ 's (greenhouse) vs. Clones (greenhouse)	31	+ .63
S ₁ 's (greenhouse) vs. Clones (field)	31	+ .20

The clone with most resistance in the greenhouse test also gave the most resistant polycross and S₁ progenies.

Orchardgrass

Selection for Resistance to Foliar Diseases

Twenty plants were selected from the nursery established in 1953 (1953 Annual Report, page 9). These plants will be cloned and compared with some of the better clones being evaluated in the northeast.

On the basis of resistance to leaf diseases and aftermath production the following clones are being placed in three isolation nurseries to produce synthetics of three maturities:

<u>Early</u>	<u>Medium</u>	<u>Late</u>
MII-30	MXI-17	Pa.-o-49
MIX-11	Pa.-o-42	Pa.-o-51
MX-7	Stag-172	MXII-5
MX-8		MXII-8
MX-14		

Another group of orchardgrass clones selected for foliar disease resistance (1953 Annual Report, pages 12 and 13) was transplanted to an isolation nursery. Seed, harvested in 1955, will be planted in plots in 1956 for comparison with other strains.

Dying-Out of Orchardgrass

In cooperation with the Agricultural Experiment Station, The Pennsylvania State University, studies are being conducted to determine the cause of dying-out of orchardgrass in southern and central Pennsylvania. Areas of dead plants were first observed in several southern counties in May 1954--usually in pastured fields. The areas varied in size from individual plant crowns to irregular-shaped areas 6-8 feet in diameter, with distinct borders. Occasionally single, small green tillers, which appeared to be growing normally, arose from the bleached crowns. White clover and bluegrass within the areas were not affected.

The location of the dead areas could not be correlated with drainage, soil type, or fertilization practices, but were scattered more or less at random. The roots and crowns appeared to be relatively free of insects.

During the summer of 1955 in experimental plots of orchardgrass at the University, the stands of one variety, S37, were greatly reduced. The dying and dead plants revealed a crown and root rot similar to those examined from the southern counties.

Examinations were made for possible pathogens from all collected material. Organisms found which might have killed the orchardgrass were: Fusarium spp., Rhizoctonia sp., Phoma sp., Pleospora phaeocomes, two Basidiomycetes, and two unidentified fungi.

In one series of inoculations, the fungi did not kill commercial orchardgrass plants. Studies are underway using different techniques of inoculation and various strains of orchardgrass, including S37.

Reed Canarygrass

Progenies of 35-Chromosome Phalaris arundinacea

Seed was harvested from the hexaploid and octoploid nurseries. The hexaploids produced seed in fair abundance whereas the octoploids were largely sterile but produced a few seeds. Seedlings were established from the seed produced on 7 clones in each nursery and chromosome numbers determined. Seedlings from the hexaploids nearly all had 42 chromosomes and the seedlings from octoploids possessed 56 chromosomes indicating that non-reduction, which presumably played a part in the origin of the 56-chromosome plants, was not a factor in these 56 chromosome progenies.

In contrast to the results in *B. inermis* the hexaploid reed canarygrass was more regular meiotically than the octoploids. Neither the hexaploid nor octoploid *Phalaris* appears to possess any characteristics that make it more desirable than the normal tetraploid. The vigor of these higher ploids seems to be somewhat less than that of normal reed canarygrass though this may well be a consequence of inbreeding in the origin of the polyploids rather than a characteristic purely associated with polyploidy.

Phalaris Interspecific Hybrids

Seed was obtained from Mr. Gialzeta of Argentina representing three types of progenies from the cross between *P. arundinacea* and *P. tuberosa*. The progenies resulted from (1) selfing $2n = 56$ derivatives of the cross, (2) open-pollination of plants with $2n = 56$, and (3) synthetic of 10 best $2n = 42$ plants. The $2n = 42$ plants resulted from open-pollination of the F_1 hybrid which was not isolated from the two parents. This material in the year of establishment is less vigorous but has retained its green color much later into the fall than reed canarygrass. Of primary interest will be the winter hardiness of the material, its fertility, and possible improvement in palatability over reed canarygrass.

Brown Stripe of Grasses

Studies have been completed on brown stripe of grasses (1953 Annual Report, page 12). Sporulation in culture was obtained by subjecting one month old single spore isolates from orchardgrass on V-8 juice agar to ultra violet irradiation. In cross inoculation studies, potted seedlings of orchardgrass and timothy were placed under either diseased orchardgrass or timothy plants held in an inoculation chamber. Orchardgrass inoculum infected only orchardgrass. Timothy inoculum infected both orchardgrass and timothy seedlings.

Helminthosporia on Grasses

Physiological studies and cross inoculations involving the Helminthosporium complex on forage crops are underway. Included in this study are H. teres, H. avenae, H. gramineum, H. dictyoides, H. siccans, H. dictyoides var phlei, Pyrenophora bromi, Pleospora phaeocomes, H. erythrospilum, H. catenarium, a Helminthosporium isolated from tall fescue and one from annual rye.

The effect of varying concentrations of dyes was determined on isolates of these species. Isolates grown on the dyes at concentrations of 1:50,000, 1:100,000 and 1:1,000,000 were studied and the amount of mycelium produced was measured at the end of 12 days. Nitrogenous compounds were tested as to their ability to serve as sources of nitrogen in a nutrient medium. A study of the pigments produced by the isolates of these species is in progress.

Studies were completed and published on Pleospora (Helminthosporium) phaeocomes on orchardgrass and H. dictyoides var phlei on timothy.

BIOCHEMISTRY, PHYSIOLOGY AND SOILS

Physiological Studies of Sclerotinia trifoliorum

Nutrient cultures of the fungus causing Sclerotinia disease in Ladino clover wilted excised clover leaves (1954 Annual Report, page 5). An explanation of this was sought.

A standard procedure of testing leaves was adopted in which the cut end of the petiole was immersed in a liquid kept below 20°C. and light was supplied by a 200 watt lamp 5 inches above the leaf surface. In the presence of a wilt-inducing substance, wilting of the petiole occurred within one hour.

Wilting could be induced by normal fungus cultures containing sclerotia but not by any culture, including degenerate cultures, that did not contain sclerotia. An exception is that normal cultures grown in the presence of isoleucine caused wilting; such cultures did not contain sclerotia but had heavily pigmented mats.

Sclerotia removed from cultures and suspended in water caused wilting as a rule. Some sclerotia which did not cause wilting did so after being heated in boiling water and cooled. Many culture solutions from which the sclerotia had been removed did not cause wilting. The ability of sclerotia to cause wilting was not lost by drying, grinding, boiling in water, heating in dilute acetic acid, soaking in cold alkali, or by digestion with pepsin. When a mass of dried sclerotia was extracted with alcohol, both the insoluble residue and the alcoholic extract, after the removal of the alcohol, caused wilting. When ground sclerotia were heated with a 0.5% solution of ammonium oxalate and the extract precipitated with alcohol, a colloidal precipitate was obtained which when suspended in water caused wilting readily. This substance was identified as a glycogen as it yielded on acid hydrolyses only glucose which was identified by paper chromatography. It is concluded that both an alcohol-soluble substance and an alcohol-insoluble carbohydrate, are present in sclerotia and each can cause wilting.

High molecular weight materials found in the laboratory such as proteins, soluble polysaccharides, enzyme preparations or ground plant materials caused wilting when in a concentration of 2% or more. Amino acids did not cause wilting.

Leaves from Ladino clover clones, both susceptible and resistant to the Sclerotinia disease, were tested. The results were inconclusive in relating susceptible clones to wilting under laboratory conditions. The same clone did not react consistently in the same way. Terminal leaves wilted more quickly than those farther back on the stolon and plants which had not been defoliated for some weeks did not respond readily to wilting influences. The use of seedlings instead of excised leaves was not satisfactory.

Carbohydrate Studies on Grasses

(In cooperation with T. G. Phillips
of the New Hampshire Station)

Studies on the polysaccharides of forage grasses were continued (1953 Annual Report, page 14). Holocellulose was prepared from a number of orchardgrass, brome grass, and ryegrass samples. From these, hemicelluloses are being prepared and will be analyzed for the different sugars they contain. The objective is to identify and compare the hemicelluloses in different parts of the grass plant, at different stages of maturity, and in different species and clones.

During 1955 the work was devoted to methodology. Steps in the preparation of holocellulose are as follows:

1. Extraction with benzene-alcohol mixture.
2. The removal of the protein by digestion with pepsin facilitated filtration in subsequent steps, especially in the more immature grasses of high protein content. This was adopted as standard practice.
3. Removal of pectin by two successive digestions with 0.5% ammonium oxalate solution. This step was found to be of relative unimportance and could be limited to one short digestion or none.
4. Four successive digestions with hot sodium chlorite followed by one cold filtration. A hot filtration caused low yields of holocellulose.

The hemicelluloses were prepared from the holocellulose by the following procedure: Four successive extractions with water at 100°C., combining of the extracts, concentration to a small volume, dialysis, and precipitation with alcohol. Over two-thirds of the hemicellulose present was recovered in this way. Alkaline extraction of the residue after the water extraction gave negligible returns.

Methods for the qualitative and quantitative determination of the sugars released from the hemicelluloses by acid hydrolysis are being studied.

Measurement of Nutritive Value of Pasture Plants

Studies were continued on the chemical composition of forages of known digestibility by sheep (1954 Annual Report, page 11). The objective is to collect data for use in predicting the nutritive value of forages from chemical analyses alone.

To date these studies have been carried out on forages fed to sheep in digestion trials at the Pennsylvania Station. Through the cooperation of the Northeast Forage Crop Technical Committee NE-24, additional materials are being made available and will be included in future studies. These are various grasses and alfalfa of known digestion values using cattle, steers, and calves, as well as sheep.

Considering only grasses of known digestion values to sheep, both digestible dry matter and digestible organic matter may be calculated from the lignin content (x) by simple regression equations as follows:

	<u>Digestible Dry Matter</u>		<u>Digestible Organic Matter</u>	
	Equation	Error	Equation	Error
36 grasses	$97.7 - 4.27x^1$	1.98	$102.3 - 4.43x^2$	1.80
15 orchardgrass	$112.2 - 6.59x^1$	2.33	$112.1 - 5.80x^2$	1.75
8 timothy	$102.2 - 4.74x^1$	1.53	$105.2 - 4.73x^2$	1.76
8 brome grass	$90.6 - 3.11x^1$	1.21	$96.2 - 3.55x^2$	1.55

x^1 - lignin in percent of dry weight

x^2 - lignin in percent of organic matter

For a more accurate prediction of digestion values or energy values from the chemical composition, some fractionation of the organic matter seems inevitable. Both alcohol extraction and acid hydrolysis are being studied. The alcohol-soluble portion of the grasses is highly digestible while the digestibility of the alcohol-insoluble portion is negatively correlated with the lignin content. Any analytical scheme permitting the calculation of digestible matter from chemical data must be relatively simple if it is to become generally useful.

Atmospheric Moisture in the Microclimate

Air and dewpoint temperatures were again taken at four heights above a clipped Kentucky bluegrass sod (1954 Annual Report, page 14). These data and those of the three previous years were published.

Plant Climate: Comparison of Plant Temperatures Air Temperatures

Temperatures of Ladino stolons growing with orchardgrass, and air temperatures at heights of 3 inches and 60 inches, were measured simultaneously. The Ladino clover-orchardgrass was managed similarly to rotational grazing. Mean monthly temperatures of the stolon ranged from 83° in July to 30° in December 1955; at the 60-inch height, from 73° in July to 25° in December; those at the 3-inch height were intermediate.

During May the average diurnal temperature range was 43° in the stolon, 32° in the air at 3 inches, and 23° at 60 inches. Similar ranges occurred during June and July. In the spring and early fall, when more vegetative growth and cover were on the plots, daily temperature ranges were smaller. During September and October, and again in November and December when light snow was frequent, greatest changes in daily air temperatures occurred at 3 inches and least in the stolon.

The frequency of occurrence of daily temperature variations was determined by grouping the number of times that different ranges of temperatures occurred. The greatest frequency of daily alternation of air temperatures during April through August at the 60-inch height was between 10-29°F., and at the 3-inch height it was 20-39°F. In the stolon, temperatures ranged most frequently between 20-49°F. Extreme daily temperature fluctuations of 50° occurred in the stolon during May, June, and July, whereas a temperature fluctuation of air at the 60-inch height was 30° or less on the same days.

Soil Temperatures Under a Kentucky Bluegrass Sod

Observations previously made (1954 Annual Report, page 15) included only a part of the year. During the summer of 1955, large diurnal variations of soil temperatures were observed near the surface with progressively less variation at greater depths. For example, on July 26 a clear day with a maximum air temperature of 97°F., the differences between the daily maximum and minimum temperatures were 35° at the 1 inch depth, 24° at 2 inches, 17° at 4 inches, 7° at 8 inches, and 1° at 16 inches.

During the winter, cooling was from the surface down. The soil was continuously frozen at the 1-inch depth beginning early in December 1954 and at the 2- and 4-inch depths in late December and early January 1955. At the 8-inch depth the soil was frozen by the last half of January and at the 16-inch depth by the first week in February. In 1955, the soil froze to the 2-inch depth in late November and early December, and was frozen at the 8-inch depth by late December. At the 16-inch depth the temperature dropped to 33° by the end of the month.

Legume Seedling Establishment

Trials were initiated to determine the rate of germination and seedling establishment of Ladino clover and alfalfa seeded at intervals on small plots from April 5 through September 2. The seed was placed by hand at 1/2-inch-depths in well prepared soil that was moist (17-23% moisture). Counts of seedling emergence were taken at intervals and general measurements were taken on plant number and size on November 2 as the plants went into the winter.

The alfalfa emerged much more rapidly than Ladino clover; 40% of the germinable seeds of alfalfa had emerged in one week and 80% in two weeks or longer, whereas with Ladino clover 5% had emerged in one week and 50% in two weeks or longer.

Summer seedings emerged more poorly: 50% of the alfalfa emerged in one week and of the Ladino clover, 5% in two weeks and 15% in four weeks. Of the seeding made in early September, 40% of the alfalfa emerged in one week and 6% of the Ladino clover in two weeks.

The extremely dry summer months resulted in no loss of plants from April or early May seedings, but a slight loss (5%) of plants occurred in the late May, July, and August seedings.

In late fall, plants from April and early May seedings were much larger (as much as 10 times) than summer and fall seedings. This was particularly noticeable in the length of roots of alfalfa as well as in height and number of branches. Root size of Ladino was much greater on seedings made earlier than May. The best stolon growth was from the earliest seeding date (April 5).

Cutting Practices as They Affect the Persistence and Production of Alfalfa

The alfalfa plots seeded in the summer of 1953 and given several cutting treatments in 1954 (1954 Annual Report, page 13) were given similar cutting treatments during 1955. One series of plots was first cut at the "pre-bud" stage (May 16), and others were cut at the "bud" stage (May 23), at the "full bud, trace of bloom" stage (May 27) and the "1/10 to 1/4 bloom" stage. Subsequent cuttings were made only when the plants had reached "1/10 bloom" stage. The last fall cutting was taken early in September or late in October, if the plants had reached "1/10 bloom" by early September. Those cut in September and which had not reached "1/10 bloom" by late October, were not cut again.

Four cuttings were obtained from all plots irrespective of the time the first cut was taken ("prebud" or "1/4 bloom") but the time of taking the first cut provided aftermath yields at various times and thus resulted in more even distribution of production during the summer.

Total production of dry matter (15% moisture basis) for the year was greatest (about 5-1/2 tons) when the first cutting was delayed until "1/4 bloom", and was 4 tons from plants cut in the "prebud" stage. Most of this difference occurred in the first cut which was 2-1/2 tons when cut at the "1/4 bloom" and 1-1/2 tons when cut at the "prebud" stage. It was apparent that herbage cut at the "1/4 bloom" stage had a much lower proportion of leaves and a much higher proportion of stem tissue than the herbage cut at the earlier stages. Observations of all treatments suggest that the "full bud" stage for the first cutting might be most practical. The "1/4 bloom" stage was more stemmy and less leafy.

There was no loss of plants during the winters of 1954 and 1955 following these cutting treatments.

The Role of Hard Seed of Ladino Clover in Natural Reseeding

Last year it was reported that hard seeds of Ladino clover exposed to low temperatures (1°C.) for several weeks germinated when subjected to alternating temperatures (1954 Annual Report, pages 16 and 17). Further studies have shown that if seeds are exposed to room temperature for a few weeks following prolonged exposure to low temperature, they no longer germinate when subjected to alternating temperatures. It appears that seeds exposed to low temperature are conditioned to germinate when subjected to alternating temperatures. However, the conditioning that occurs at low temperature is lost if the seeds are subsequently exposed to room temperature for a few weeks.

These results, together with those obtained from seeds buried at different depths in the soil, indicate that most hard seeds at or near the soil surface will germinate in the spring during the period of daily alternations in temperature. This is true whether the seeds were on the surface of the soil during the winter or were plowed up early in the spring. If the seeds are plowed up during the summer, they will not germinate because of lack of adequate fluctuation in temperature. Moreover, the conditioning process that occurred during the winter will be nullified by the high temperatures of summer, so that relatively little germination will occur during the period of alternating temperature in the fall. If the seeds remain at the soil surface most of them can be expected to germinate the following spring.

Responses of Grasses vs. Legumes to Phosphorus and Potassium Fertilization

Experiments have been conducted over a three-year period to determine the responses of pure stands of alfalfa and of orchardgrass to both phosphate and potassium fertilizers on a Hagerstown silt loam of moderate fertility (1954 Annual Report, pages 19 and 20). Nitrogen fertilizer was applied uniformly to the grass after each cutting. The average response to phosphate over the three-year period was only slightly higher for alfalfa than for orchardgrass.

The responses to potassium fertilizer are of particular interest, in that during the third year the increase in yield was greater in orchardgrass than in alfalfa, both on a percentage basis and in pounds per acre. (Statistical significance of these differences has not yet been calculated).

Plant analyses show that orchardgrass is considerably higher in percentage potassium than is alfalfa. Thus it would appear that the greater response of orchardgrass to potassium may be attributed to a greater rate of potassium depletion of the soil.

Fertilizer Placement for Perennial Forage Crops

Experiments were continued to evaluate the relative efficiency of phosphate applied in bands vs. mixed with the soil for seedings of alfalfa (1954 Annual Report, page 18). Seedings were made in late April and early May, and followed by the driest May on record. Stands were so poor that no conclusions could be drawn from the field plots.

Greenhouse studies were conducted with soils brought to varying levels of available phosphate by incubating with various rates of phosphate prior to seeding. It was found that on soils low in available phosphate, banding of phosphate directly below the seed gave markedly better seedling

growth than where the phosphate was mixed with the soil. With soils of higher levels of available phosphate, the advantages of band applications of phosphate were smaller.

In greenhouse trials with alfalfa, the time of harvest was a major factor determining the relative efficiency of band applications of phosphate. For the first 10 days following emergence no response to phosphate could be observed regardless of method of placement. About two weeks after emergence, response to phosphate was noted and for the next two or three weeks the rate of growth was particularly rapid where phosphate was banded. Thereafter differences in yield from phosphate applied in a band as compared with mixed throughout the soil gradually decreased and at the end of 10 weeks were rather small.

Further studies are in progress to determine the interrelations of temperature and level of phosphate fertility on seedling responses to band placement of phosphate fertilizer.

Response of Various Perennial Forage Crops to Irrigation

This was the second harvest year of an experiment to determine total and seasonal distribution of yields of alfalfa, birdsfoot trefoil and 8 grasses under heavy fertilization, both with and without irrigation (1954 Annual Report, pages 19 and 20). All species were liberally fertilized with phosphate and potash, and the grasses received nitrogen after each cutting. Management simulated an early cut hay followed by clipping to simulate rotation grazing. The frequency of clipping depended upon the rate of recovery, ranging from every 3 or 4 weeks for orchardgrass and perennial ryegrass to about 5 weeks for tall oatgrass, timothy, reed canarygrass, and brome grass. The results this year under irrigation were in sharp contrast to those obtained the first harvest year when all species grew well throughout the season. This year under irrigation the stands of several of the grasses thinned out rapidly during the summer. Recovery in the fall, following a dry summer, was generally much poorer on plots that had been irrigated than on those subjected to rather severe drought.

The results to date indicate that tall oatgrass, brome grass, and timothy are poorly adapted for midsummer irrigation, regardless of rate of fertilization. Orchardgrass is perhaps the most promising. Alfalfa, on the other hand, was highly productive during midsummer even without irrigation.

Soil Compaction in Permanent Pastures

(In cooperation with L. T. Kardos
of the Pennsylvania Station)

The results again show that rate of infiltration increased rapidly following soil compaction (1954 Annual Report, page 77). Immediately following compaction in late April, runoff on small plots receiving 1-1/2 inches of simulated rainfall in one hour averaged 78%. Two weeks later runoff during simulated rainfall was only 34%. During this two-week period natural rainfall was only 0.1 inch and shrinkage cracks developed in the soil. Soil treatment to control earthworms had no apparent effect on infiltration rate of compacted soil. Because of dry weather, however, earthworm activity was very low compared with last year.

Total runoff during the season from natural rainfall was 0.6 inches from compacted plots and 0.1 inch from non-compacted plots. Yields of forage in the non-compacted plots from May 9 to September 1 were about 1 ton per acre. Dry weather lowered yields somewhat. Compaction decreased yields about 16%.

REPORT OF COOPERATIVE RESEARCH

Title: PROJECT NE-13 - THE MECHANIZATION OF FORAGE CROP HARVESTING, PROCESSING, STORING AND FEEDING.

Leader: W. C. Wheeler, Chairman, Regional Technical Committee

Cooperators: Storrs (Conecticut), Maine, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, Vermont, and West Virginia Agricultural Experiment Stations with technical assistance and contributing projects by the USDA - A.R.S. Agricultural Engineering Research Branch, Beltsville, Maryland

Forage constitutes the largest tonnage handled on farms in the Northeast. In most cases it must be handled more than one time and this requires considerable labor and/or equipment. Constantly increasing forage yields and increased emphasis on forage quality have magnified the harvesting, handling and storage problems. In a move to coordinate the efforts of the states in the Northeast in solving these problems, the regional project was initiated on July 1, 1954. The objectives for the project are, to determine the job and mechanical requirements and to develop methods and equipment for the production of quality forage with special reference to the operations of: (1) Harvesting, (2) Processing, (3) Storing and (4) Feeding. Each of the contributing states has projects which include one or more phases of the objectives.

(1) Harvesting. To date this phase of forage handling has probably received the greatest attention from industry as evidenced by presently available equipment. Definite problems still exist and are receiving study. Tires having a low inflation pressure, more efficient field equipment and more efficient handling methods are being investigated by Massachusetts to reduce soil compaction during forage harvesting operations. A determination of the basic power requirements for cutting and handling forage crops should be helpful in the design of better equipment and machines. Connecticut is presently making power studies of the cutting operations, West Virginia is studying silo unloader design and Maine plans to conduct a power study on wagon unloaders. Bale drags, tractor buck rakes and a modified bale loader are being used by Maine in the search for an efficient method for field handling of baled hay. New Jersey and West Virginia also have field-handling-of-baled-hay studies which are part of other phases of the project. Various methods and equipment are being compared by A.E.R.B. - A.R.S. - U.S.D.A. in determining rates of harvesting and storing as related to forage dry matter content and labor and equipment required.

(2) Processing. Major emphasis in this phase of the project is on hay drying (baled and chopped) with air (heated and unheated). Distribution patterns for the flow of air in a corn drier and also in a multi-level duct system for drying chopped hay in a narrow mow are under study at Pennsylvania. Detailed studies of the fundamentals of drying (baled hay by New Jersey, chopped hay by Pennsylvania) are under way. Various designs of wagons, controls and air conditions will be used in these studies. A batch drier for baled hay is under study at West Virginia where both fuel oil and coal are used in the drying tests. Electrodes and meter circuits with calibration curves for indicating the moisture content of grain have been perfected by New Jersey with the search continuing for a suitable device to use on windrowed and baled hay.

(3) Storing. The seasonal nature and high labor requirements for getting forage crops into storage make this an important phase of the project. Present commercial forage blowers are not ideal for moving forage crops and are under study at New Jersey. The efficiency of silage wagon unloading operations has been improved at Maine by using unloading devices that give a more even flow of forage into the blower. Two types of these devices have been used as an integral part of the hauling vehicle. Tests will be run during the coming year with one of these devices mounted independently increasing its availability to more than one vehicle. Pneumatic handling offers a possible solution to the chopped hay handling problem and tests are under way at Maryland using this method. A silage distributor for self-feeder silos has proved satisfactory at New Jersey. The use of elevators for handling forage crops apparently has much greater potential than is being utilized. Modified commercial models and specially designed elevators and conveyors are being used in studies with chopped hay at New York and Pennsylvania. Considerable time and labor are saved at West Virginia by using a conveyor to move baled hay into and out of a batch drier.

(4) Feeding. Any mechanization or improvement of structures that will reduce the chore time for feeding forage will certainly be welcomed. A study at New York of the operational characteristics for six mechanical silo unloaders should be helpful to farmers that are considering buying one. West Virginia experienced difficulties with a silo unloader that was being used in mechanical vs. hand unloading studies. The unit required modification before it would operate satisfactorily. A mechanical manger conveyor feeder for dairy cows has proved satisfactory at Vermont. A similar type unit of improved design is being installed and will be used in conjunction with a bulk bin and semi-automatic metering device for dairy rations. Each year New Jersey has made significant improvements in a self-feeding silo. Other types of self-feeding structures that look promising are a drying and self-feeding barn at Pennsylvania and a pole type barn with horizontal silo at West Virginia.

The scope of this project on the mechanization of forage crops is very broad. Personnel and facilities will not permit a study of all the problems involved. It is expected that the contributing states will undertake other problems as they arise and as additional personnel and facilities become available.

Title: PROJECT NE-18 - ECONOMICS OF FORAGE PRODUCTION AND UTILIZATION

Leader: I. F. Fellows, Chairman, Regional Technical Committee

Cooperators: Connecticut (Storrs), Delaware, Maine, Massachusetts, New Jersey (Rutgers), New York (Cornell), Pennsylvania, Rhode Island, Vermont, West Virginia Agricultural Experiment Stations and Production Economics Research Branch, A.R.S., U.S.D.A.

The regional project was initiated July 1, 1954. Some of the state contributing projects were activated immediately; others were begun in the following crop year because of nature of the problems under study. Therefore, only preliminary results are available from most of the projects.

The state projects contribute to one or more of four sections of a regional outline developed to stimulate a regional emphasis.

Section I - Present Patterns of Production and Utilization: In eight of the contributing projects, descriptive information of existing forage production and utilization practices has been obtained from samples of operating farms. Summaries of these data show organizational characteristics of the farms, the methods and materials used in producing and harvesting forages, and farm business analyses. Relationships between the business analyses and such factors as soils, kinds of crops, harvesting methods, types of enterprises, and size of business are under study.

From these data it will be possible to give a general description of practices used by dairymen in various areas of the region and to have indicators of some of the physical and economic relationships under existing management practices.

Section II - Input-Output Relationships in Forage Production: In addition to a descriptive phase, specific input-output relationships and their economic implications are under study in most state-contributing projects. In Rhode Island comparisons are being made between land, equipment, and labor inputs and milk output when a Ladino pasture mixture is pastured or is cut and hauled to the cows.

Information from this controlled experiment is being compared with data from farmers who are also cutting and hauling pasturage to their cows. New Jersey and Massachusetts are studying similar relationships on farms where pasturage is harvested with equipment.

New York, Maine and Rhode Island have compared labor and machine-inputs when different patterns of forage harvesting equipment were used, and similar comparisons will be made in West Virginia. The New York and Maine studies give average investment and cost per farm and per ton of hay equivalent for alternative methods.

As one phase of a pasture renovation study, workers at Pennsylvania have preliminary results on the relationship between observed cover by types of pastures and the output as measured by clipping and weighing. The methods give considerable promise as a quick approximation but further evaluation is to be made.

Section III - Input-Output Relationships in Forage Utilization: determination of the technical relationships between various forages and other sources of nutrients and the economic effects of substitutions between the various nutrient sources is under study at two stations. At Rhode Island an experiment in cooperation with dairy nutrition scientists will measure the effect on milk output of two combinations of hay and silage. Results will not be available for some time. At Connecticut, technical relationships as provided in U.S.D.A. Technical Bulletin No. 815 were used to determine the best combination of concentrates and forage and the levels at which these would be fed under Connecticut price and cost conditions.

Section IV - Economic Effects of Alternative Production and Utilization Practices on the Farm Business: The impact of changes in forage production and utilization practices is a major phase of the regional research in five state projects. Possible change in farm organization, in the kinds and amounts of inputs and outputs, and in farm income will be tested by budgeting the alternatives. Comparison between present and possible patterns should stimulate farm operators to improve production efficiency and also provide the guides for types of adjustments.

Results of the research, some of them only in a preliminary form, are already being used. Extension programs in Connecticut, Maine, Massachusetts, New York, New Jersey, and Vermont have used the results in their educational programs. The New York and Connecticut work has been useful in progress of the Farm and Home Development Program. New York information on the sample area has been of value in an associated milk marketing problem.

In studies of the estimated income effects of changes in forage production or utilization, substantial improvement in net income especially for dairymen with 15 to 30 cows has been shown and has stimulated changes in farm operation.

Title: PROJECT NE-24 - THE NUTRITIVE EVALUATION OF FORAGES

Leader: C. R. Richards, Chairman, Regional Technical Committee

Cooperators: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, West Virginia, Vermont Agricultural Experiment Stations, U. S. Regional Pasture Research Laboratory and Dairy Husbandry Research Branch, A.R.S., U.S.D.A.

NE-24, The Nutritive Evaluation of Forages, was initiated July 1, 1955. It is a result of the realization of the Technical Committee of former NE-21, "Establishment, Persistence, Productivity, and Feeding Value of Perennial Forage Species in the Northeast," that the determination of nutritive value of the various forages, in the final analysis, must be made using animals. Agronomic data such as yield, persistence, establishment, etc. must be supplemented with data on the usefulness of the forage to livestock, measured in such ways as palatability, digestibility and protein content. The experiment stations of the Region were invited to send an animal nutrition representative to the annual meeting of NE-21 held in January 1955. At that time the Technical Committee for the present project was organized.

The objectives of the project are: (1) To evaluate various forages grown under known conditions and harvested at specific stages of maturity by determining digestible protein and digestible energy; and to measure the annual harvest of nutritive value by taking into account both acreage yield and nutritive value per unit of dry matter (The determination of digestible dry matter may be substituted for digestible energy in grazing experiments.) (2) To develop methods for the nutritive evaluation of forages; these to include the use of small animals and chemical analyses. (3) To conduct animal production trials simultaneously insofar as possible.

All stations with contributing projects have their work in progress at this time, but little in the way of results can be reported as so little time has elapsed since the start of the project. From investigations conducted prior to the activation of NE-24 the New York station has

shown that the digestibility of forages (first growth) is closely related to the date of cutting. (Different plant species appear to have approximately the same digestible dry matter content when harvested on the same calendar date.) Also from previous work, New York has reported preliminary data indicating that the decreasing digestibility found with increasing plant maturity is due to reduced digestibility of the leaves and a markedly reduced leaf yield, while the digestibility of the stems is much lower than that of the leaves but is relatively unaffected by advancing maturity.

Investigations to accomplish objective number one are underway at all contributing stations. Several forages grown and harvested under defined conditions and time of harvest are being evaluated, among these are: Alfalfa at one or more physiological growth stages (Delaware, Maryland, New Hampshire, New York, Pennsylvania and Rhode Island); red clover at three growth stages (Rhode Island); various legume grass mixtures (Massachusetts, New Hampshire, Pennsylvania, and Delaware); orchardgrass grown with three levels of nitrogen fertilization (New Jersey).

The animals currently being used in the digestion trials are dairy cows (Maryland, Delaware, and Massachusetts), steers (Maryland, New York), dairy heifers (New Hampshire, Rhode Island); sheep (Delaware, New Jersey, New York and Pennsylvania); rabbits (Delaware).

For objective number two, indicator methods are being used at Delaware, Maryland, New York and Massachusetts. Pennsylvania is determining metabolizable energy as well as digestible energy. New Hampshire is determining net energy (energy utilized) in addition to digestible energy, metabolizable energy and T.D.N. All contributing stations are making chemical analyses of forage and feces with the aim of improving the estimation of nutritive value by chemical determinations. Several stations are furnishing samples of forage and feces to the U. S. Regional Pasture Research Laboratory where a major effort is being made to improve the chemical evaluation of forages.

In an effort to establish whether nutritive evaluation of forage made with one species of animal applies to other species of animals, New Hampshire is using heifers for the evaluation and is sending some of each forage to Pennsylvania for evaluation with sheep. Maryland, using steers and dairy cows, is also sending forages to Pennsylvania for evaluation with sheep. Delaware is making comparative evaluation with sheep and rabbits.

Production trials with lactating cows are being made at Maryland, New York, and Massachusetts with forages for which the digestible energy, digestible protein and other evaluations have been or are being made simultaneously. New Hampshire is determining the utilization of protein and energy simultaneously with digestibility evaluations.

Title: PROJECT NE-28 - BREEDING AND EVALUATION OF IMPROVED VARIETIES OF FORAGE CROPS ADAPTED TO THE NORTHEAST (INITIATED JULY 1, 1955) AND NE-21 PHASE III - ESTABLISHMENT, PERSISTENCE AND PRODUCTIVITY OF REGIONALLY DEVELOPED STRAINS OF PERENNIAL FORAGE CROPS (JANUARY 1, 1955 TO JUNE 30, 1955).

Leader: R. P. Murphy, Chairman, Regional Technical Committee

Cooperators: Connecticut (Storrs), Maine, Maryland, New Hampshire, New Jersey, New York (Cornell), Pennsylvania, Rhode Island, Vermont, West Virginia Agricultural Experiment Stations, the U. S. Regional Pasture Research Laboratory, and the Field Crops Research Branch, A.R.S., U.S.D.A.

Under NE-21 research was initiated with birdsfoot trefoil, smooth brome-grass, and orchardgrass and plans were also made for the production of seed of the alfalfa selections through the cooperation of Dr. H. O. Graumann of the Field Crops Research Branch, A.R.S., U.S.D.A. Under NE-28 this research is being continued and expanded and plans were developed to include research on Ladino clover and timothy but no experiments were initiated with these crops in 1955.

The breeding procedure followed with each crop is to test selected clones, their polycross progeny, and selected experimental synthetic varieties produced from the elite clones as determined by their performance and their progeny's performance. The selected clones which are the basis upon which this method of breeding is founded represent the best that are available from the various experiment station research programs. Their value on a regional basis is determined through this project and the synthetics are compounded from a selected elite sample from the entire group based upon their regional performance. Other experimental and standard varieties are used as checks.

With orchardgrass several of the selected clones were found to be leafier, later in maturity, and more resistant to disease than the checks. It appears that several new promising experimental synthetic varieties may be developed from these materials. In the early group of varieties Potomac, the recently released variety which was tested under NE-10, was the highest in yield and freest of disease. In the late-maturing group N.Y. D appears to be the most promising and should be carefully observed in further tests. Cytological studies of the clones are in progress by Pennsylvania.

With smooth brome grass a number of the new selected clones appeared promising especially for increased aftermath production. Among the new varieties in test Saratoga, named and released by New York in 1955, performed well. It was the highest in total season and aftermath yield. This variety was also tested under NE-10 and NE-21.

With birdsfoot trefoil only a few of the selected clones appeared to be promising. In the variety test one experimental selection, LC-54, was promising in yield. Viking and Mansfield were superior to other early varieties in yield. The tetraploid selection of narrowleaf from Vermont was high yielding in the first cutting but was lower than any of the broadleaf varieties in the second cutting.

With alfalfa the selected clones were distributed to the cooperating stations. Polycross seed of these clones and seed of three experimental varieties was produced in the West in 1955 through the cooperation of Dr. H. O. Graumann and others in the Forage and Range Section of the Field Crops Research Branch, A.R.S., U.S.D.A. The clonal, polycross and experimental variety tests of alfalfa will be established by the cooperating stations in the spring of 1956 now that seed of these is available. The following stations cooperated in 1955 in these tests: orchardgrass (New York, Pennsylvania, and Maryland); smooth brome grass (New Hampshire, New York, and Pennsylvania); birdsfoot trefoil (Vermont, New York, and Pennsylvania); alfalfa (Maine, Connecticut, Rhode Island, New York, Pennsylvania, New Jersey, and West Virginia).

From these preliminary data (first harvest year) promising selected clones for the development of improved varieties are being identified especially in orchardgrass and brome grass. One or more of the experimental varieties of orchardgrass, brome grass, and birdsfoot trefoil appear very promising and warrant further and more extensive testing. The data give more evidence on the superiority and regional adaptation of the new varieties such as Potomac orchardgrass, Saratoga smooth brome grass, and Viking and Mansfield birdsfoot trefoil. The results of regional testing such as this helped bring about the acceptance and increase of Narragansett alfalfa and Pennscott red clover which are becoming very important varieties in the Northeast as rapidly as supplies of certified seed are produced. The new varieties mentioned above may follow this pattern and some of the experimental varieties may follow it if the data from continued testing confirm their superiority.

The tests with orchardgrass, smooth brome grass, and birdsfoot trefoil will be continued and some additional tests may be established by the cooperating stations. The tests with alfalfa will be established in the spring of 1956. In 1956 New Jersey will establish a birdsfoot trefoil experiment and Maryland and New Hampshire will initiate studies with Ladino clover.

Mimeographed summaries of the data from all of the tests have been distributed to the members of the Technical Committee and the cooperating U.S.D.A. research groups.

Title: PROJECT NE-29 - ESTABLISHMENT AND MANAGEMENT OF PERENNIAL FORAGE SPECIES AND VARIETIES FOR PERSISTENT PRODUCTION IN THE NORTHEAST. PHASE I - SEEDLING ESTABLISHMENT AND EARLY DEVELOPMENT OF FORAGE GRASSES AND LEGUMES AS AFFECTED BY CULTURAL TREATMENT. PHASE II - PERSISTENCE, PRODUCTIVITY AND GROSS NUTRIENT VALUE OF PERENNIAL FORAGE CROPS AS INFLUENCED BY MANAGEMENT PRACTICES.

Leader: H. A. MacDonald, Chairman, Regional Technical Committee

Cooperators: Connecticut (Storrs), Maryland, New Jersey (Rutgers), New York (Cornell), Pennsylvania, Rhode Island, Vermont, West Virginia Agricultural Experiment Stations, and the U. S. Regional Pasture Research Laboratory, and the Field Crops Research Branch, A.R.S., U.S.D.A.

This regional research project was originally initiated July 1, 1954, as Phase I and II of Regional Research Project NE-21. This latter project was reorganized after one year's duration into three separate regional projects dealing with three separate but closely related subjects (1) forage crop breeding (NE-28), (2) forage crop seeding and management (NE-29), and (3) forage crop utilization (NE-24). The regional project herein reported deals with the second item listed above and was initiated as Regional Project NE-29 with the reorganization July 1, 1955.

This study has four primary objectives, namely (1) to determine the effect of various methods of seeding and of fertilizer application and placement on the establishment and development of forage crop seedings, (2) to determine the effect of different cropping and clipping practices on establishment, early development and winter survival of forage grasses and legumes when seeded with and without a companion crop, (3) to determine the interrelationship of species, cultural methods, management systems and climatic factors as they influence seeding establishment, and (4) to determine the influence of seeding methods and management practices on the eventual yield, composition and persistence of forage crop seedings.

Information on seeding establishment under Phase I is being obtained from two basic experiments. A. Seed placement and fertilization practice with experiments at Connecticut, Maryland, New Jersey, New York and Pennsylvania, and B. Early management of established seedings at Connecticut, Maryland, New Jersey, New York, Pennsylvania and Vermont. In addition to the seedings established for study in 1954, seven additional experiments were established in the spring of 1955 to study the effect of various rates of fertilizer application and placement of fertilizer and seed. Eight new experiments were started to study the effect of first year management practice on seeding success. The tests were established with the aid and cooperation of the Agricultural Engineering Section, U.S.D.A., using specialized machinery developed for accurate and uniform seed and fertilizer placement.

Successful seedings were made at all cooperating stations in the spring of 1955. Observations were made on the development of the seedings under the various treatments. Clipping treatments were applied to seedings of alfalfa-bromegrass, birdsfoot trefoil-timothy and Ladino clover-orchardgrass with and without companion grain crops. Climatic data were obtained at all stations to be used in the interpretation of the results on a regional basis. Plant response measurements were made on rate of emergence, height and vigor of seedling plants, number of tillers, established plant population, weediness, weight of plant tops and roots and total yield. Production of dry matter in the first crop year was determined for the 1954 seedings.

Almost all stations found an increase in rate of seeding establishment, vigor and eventual yield with increase in fertilizer application. Seeding emergence was generally benefited by seed and fertilizer placement, especially where seeding was made in dry situations or followed by deficient-moisture conditions. Localized seed placement was beneficial where the fertilizer was banded near the seed but did not show the same advantage where the fertilizer was broadcast. There was much variation in the results of this study between stations. This was directly related to the conditions of the local soil and environment during the season of establishment. In general the benefit from precision seed and fertilizer placement was confined to soils of less than optimum fertility and moisture at the time and immediately following seeding.

Information similar to that outlined above was collected for the studies under experiment B. In general the use of companion crops reduced the stand of both weeds and seeded forage crop species. All stations reported better results where the companion crop was omitted. Early removal of the companion crop as hay or pasture benefited the seeding. Frequent clipping of the new seeding was in all cases injurious to the alfalfa seeding and beneficial to the Ladino clover. The effect on birdsfoot trefoil was intermediate. The poorest results were found where the seedings were not

clipped during the year of seeding. In general best results were obtained with a single clipping taken in July. Most stations reported little difference in yield in the first harvest year following treatment. These results are as yet preliminary.

Phase II of this investigation is as yet not sufficiently advanced for firm conclusions to be drawn. Differential harvest cutting dates and frequencies were applied to all established trials. Preliminary results indicate less lodging of alfalfa following early first harvest. Ladino clover was benefited by frequent harvest in the first year. Since persistent production is the objective of this study future years will demonstrate the value of the treatments imposed and point to the best harvest system for optimum forage yield and quality.

Many of the results obtained to date are as yet preliminary since the climatic factor is one of the principal variables in this study. Fundamental information relating to the establishment, early development, and survival of forage seedings is being obtained. These results will have a profound influence on seedbed preparation, seeding methods, fertilizer usage and placement and management in the seeding year. Present evidence indicates that much can be done to alleviate the problem of seeding failure which is today one of the principal hazards in hay and pasture production. The need for a precision grass and legume seeder seems amply demonstrated.

PASTURE RESEARCH AT STATE STATIONS

STORRS (CONNECTICUT)

Title: ALFALFA EXPERIMENTS

Leaders: B. A. Brown, R. A. Peters and E. J. Rubins

(a) Fertilization: For the fourth consecutive year on the same plots, little, if any, benefit has been derived from adding NaCl even where KCl was applied at very low rates and potassium deficiency was much in evidence. Analyses show little Na was absorbed by the alfalfa. On the other hand, increasing rates of potassium have maintained better, more vigorous stands and produced higher yields. However, the results have been nearly as satisfactory with 120 as with 240 pounds of K_2O per acre, annually.

On a soil with a "medium" amount of available P before seeding, the first month's growth of alfalfa was approximately twice as great where superphosphate was banded at low to very high rates one inch below the drilled seed as where the same amounts of superphosphate were broadcast and disked in. Banded muriate of potash, ammonium nitrate or limestone had little effect on seedling growth. However, both the potash and the limestone were beneficial in the first harvest year.

(b) Alfalfa Varieties: A five-year test of 23 strains and varieties was terminated at the end of the 1955 season. Excepting "Kansas commercial" of unknown ancestry but possibly uncertified Buffalo, only the wilt resistant varieties of Ranger and Buffalo had stands worthy of being kept (in farm practice) for future years. Atlantic, with a 25% stand, was far superior in longevity to Narragansett which finished with only 7%. Other varieties in this experiment were: Common, Viking, Rhizoma, Talent, Grimm and Variegated. Varieties with much wilt in previous years had the poorest final stands. The acre yields of dry matter in 1955, including weeds and grasses, varied from 8500-5200 pounds.

In the fourth harvest year of another test with 30 varieties, none of the 16 unnamed ones ranked lower than 17 in yields; the only named variety among the top 17 was Ranger; and the only named ones among the leading 20 were Ranger and Buffalo. The other varieties are listed here in order of decreasing yields in 1955: Nomad, Williamsburg, Common (Kansas), Atlantic, Narragansett, Talent, Grimm, Variegated, Chilean and DuPuits. The acre yields of dry matter ranged from 6500-1600 pounds. Although this test was located on an area which had never grown alfalfa, prevalence of wilt was again associated with poor stands and low yields.

(c) Management: Cutting 1954 seedings of either Buffalo or Rhizoma alfalfa every 21 days in 1955 nearly eliminated them; mowing every 28 days reduced their stands to about 20%; while a thirty-five day interval between harvests was much less harmful. Frequency of cutting was associated with lower percentages of dry matter in the roots. Fertilization with different rates of K, with or without N, had little influence on the stands during 1955, the first year of differential cuttings. In a previous test, Rhizoma maintained much better stands than Buffalo when both were cut four times per season at 30 day intervals.

Title: THE MAINTENANCE AND IMPROVEMENT OF PASTURES

Leaders: B. A. Brown and R. A. Peters

The Adaptability of Varieties and Species of Grasses and Clovers for Pastures.

Ladino Clover Fertilization: Probably the most pressing Ladino problem in the Northeast is how to lengthen the duration of Ladino seedings. In the long-time management experiment with Ladino-grass seedings of 1939, two factors were found to be of prime importance: (1) close to the ground mowing (2-inch-stubble), and (2) liberal, annual applications of potash.

Recent results from that 16-year old stand are quite interesting and rather startling. Under the "new treatments", started in the spring of 1954, the results were as follows:

<u>Treatments 1954 and 1955*</u>	<u>% Ladino August 1955</u>
Mowed, no fertilizer nitrogen	56
Mowed, nitrogen at 50 lbs. after each cutting	32
Grazed, no fertilizer nitrogen	31
Grazed, nitrogen at 50 lbs. after each grazing	3

*Liberal LPK in all cases.

Thus, it appears that either nitrogen or grazing reduced the stands of Ladino and it was nearly eliminated when both nitrogen and grazing were included in the treatment.

On the mowed plots, the acre yields of dry matter were increased about 1000 pounds (20%) by the 200 pounds of nitrogen in 1955. The difference in green yields in 1954 was 5400 pounds (12%) in favor of the nitrogen plots.

The 1955 records on the grazed portions of the field were:

	<u>Heifer Days</u>	<u>Pounds Gained</u>
With nitrogen	176	301
No nitrogen	134	337

During the sixteen years the yields of the 1939 Ladino seeding have been determined, the largest yields were obtained in 1945 and the second highest in 1953. A positive correlation existed between stands of Ladino and yields of dry matter.

That the long life of the 1939 seeding is not an exceptional case is shown by a Ladino-orchardgrass fertilization experiment started in 1949. With moderate limestone-superphosphate treatments and four mowings per year, the effects of potassium are illustrated below:

<u>Potash (K₂O)</u> <u>(lbs./acre)</u>	<u>% Ladino</u>		<u>Dry Matter</u> <u>(cwts./acre)</u>	
	<u>1950</u>	<u>1955</u>	<u>1950</u>	<u>1955</u>
720 in 1949, none since	45	5	60	28
60 annually	35	21	57	38
120 annually	38	50	55	56
180 annually	48	58	66	61
240 annually	62	61	68	53

Potash is more efficient when added in frequent, smaller amounts. For example, the results for five harvest years showed that a Ladino-orchardgrass seeding averaged about 20% more Ladino and 12% more dry matter when the same total amount of potash was divided into four applications, instead of one per season. The K content of the herbage was also much more uniform.

The source of phosphorus has also been an important factor. During the 1950-1955 period, eight rock phosphate treatments averaged 40% Ladino and 50 cwts. of dry matter, while the corresponding values for six superphosphate treatments were 48% Ladino and 61 cwts. of dry matter.

Liberal liming of this acid (pH 5.5) soil has had an appreciably favorable effect on the stand of Ladino.

Rather small amounts of nitrogen have reduced the prevalence of Ladino appreciably but have increased yields of dry matter slightly.

Sudangrass Varieties: In previous years, Piper Sudangrass has yielded more than the other varieties. In 1955, however, there was little difference between Piper and Sweet.

Both varieties grew much better on superphosphate, fused tri-calcium phosphate and calcium meta phosphate than on raw rock phosphate.

Title: USE OF HERBICIDES IN FORAGE CROP MANAGEMENT

Leaders: R. A. Peters and B. A. Brown

(a) Control of Quackgrass (*Agropyron repens*) and Kentucky Bluegrass (*Poa pratensis*) in Established Alfalfa Stands: Dalapon applied as growth was starting in the spring gave very good top growth control of quackgrass at 5 and 10 pounds acid equivalent per acre without significant damage to the alfalfa. Forty pounds of sodium TCA was no more effective than the 5-pound rate of Dalapon.

Dalapon applied in mid-November at rates of 4, 8 and 16 pounds acid equivalent per acre controlled bluegrass and orchardgrass up to the time of the first cutting. Applications made the first of April were more selective with the bluegrass being reduced considerably more than the orchardgrass at the lower rates.

(b) Use of Chemicals for Pasture Renovation: Dalapon has proven to be the most effective chemical to date for killing Colonial bent and Kentucky bluegrass. Heavy rates of CIPC up to 80 pounds per acre applied in the cool season have been effective, but the cost is prohibitive.

When Dalapon has been applied in the late summer, an excellent seedbed for frost-crack seedings has developed by spring. Frost action heaves many of the dead grass plants, leaving a rough surface in which seed may lodge.

While in several tests initial establishment of the broadcast forages has been obtained, satisfactory stands have seldom been present at the end of the season. Competition of the species originally present becomes limiting before the end of the frost season. In the poorer pastures perennial broadleaf weeds such as robin's plantain, plantain, yarrow, wild carrot, etc. are quite frequent in the stand. These species are not killed by Dalapon nor by single applications of 2,4-D. Their growth is stimulated after the sod is killed, presumably by the nutrients being released by the dead sod. Where supplemental tillage is used, these weeds are considerably less competitive.

Title: EFFECTS OF FERTILIZATION ON THE PREVALENCE OF WHITE AND RED CLOVERS IN PERMANENT GRASSLAND

For 23 years (1931-1953) the stands of native clovers on 5 acres of strongly acid (pH 5.5) and badly depleted Paxton fine sandy loam soil were estimated each year, usually in June before mowing for hay and in August before starting periodic grazing. This project was terminated in 1953. The effects of differential fertilization and liming upon clover stands are summarized in the following statements:

1. No carrier of a single plant nutrient had much effect.
2. No combination of any two materials selected from dolomitic limestone, superphosphate, and muriate of potash resulted in relatively large amounts of clovers.
3. Good stands of clovers prevailed only when enough dolomitic limestone was applied to maintain the pH of the surface (3-4 inches) soil at pH 6 or above; plus superphosphate to supply the annual equivalent of 60-70 pounds P_2O_5 per acre, with applications not over 3 years apart; and muriate of potash to furnish at least 120 pounds K_2O per acre annually. These better stands averaged 47% clover from 1945-1953, in contrast to 9% under the poorer fertility treatments.
4. Nitrogen at 30-40 pounds annually, even though added to the full LPK treatment outlined in (3), markedly depressed clover stands and increased grass growth. This was true regardless of nitrogen carrier used, including nitrate of soda, sulphate of ammonia, cyanamid, and urea.
5. Stable manure at 10 tons annually or at 20 tons biennially, applied either in the fall or spring, with or without supplementary superphosphate and with lime, also produced much less clover and more grass than the full LPK treatment of (3).

6. With liberal lime and potash, very large applications of superphosphate depressed the clovers, possibly because of the greatly invigorated stands of Kentucky bluegrass.
7. After a few years of liberal LPK treatments, omission of K decreased the clovers first, superphosphate second, and limestone last.
8. Carriers of B, Mn, Cu and Zn, alone or together, did not influence the stands or growth of the clovers treated with LPK.
9. Large annual fluctuations in clover stands resulted regardless of fertilization practices, indicating that other undetermined factors were important in affecting their prevalence.

Title: PENETRATION OF TOPDRESSED LIMESTONE INTO SOIL OF UNTILLED GRASSLAND

The penetration of dolomitic limestone topdressed on Paxton fine sandy loam in 1930 at rates ranging from 1-16 tons per acre has been presented in part in previous reports. Data are now available for 1953, 23 years after the limestone applications were made. These are summarized briefly as follows:

1. The surface inch of soil from all plots, excepting those which received limestone at 16 tons in 1930, had practically the same pH values as the unlimed ones.
2. Below the surface inch of soil increases in pH values were still very conspicuous in 1953 for all the plots, excepting those which had only 1 ton of limestone in 1930. The soil layers in which these pH increases occurred were as follows: 2-ton plots - 4-8 inches; 4-ton plots - 4-10 inches; 8-ton plots - 2-24 inches; and 16-ton plots - 1-30 inches.
3. The pH changes from 1939-1953 clearly show that lime was being lost from the upper layers to the lower levels. For example, the average decrease in pH in the 0- to 5-inch horizon of the 16-ton plots was 0.5. The corresponding increase in pH from the 6th to the 30th inches was also 0.5. Decreasing organic matter content and exchange capacity with increasing depth would appear to explain the relatively large volume of soil in which the pH rise occurred.

MAINE

Title: BREEDING AND EVALUATION OF FORAGE CROPS

Leader: L. H. Taylor

Forage nurseries and trials at both Orono and Presque Isle came through the winter of 1954-55 in very good condition. An unusually large amount of red clover from the trials planted in 1953 at Presque Isle persisted into the second harvest year. This was believed due to the excellent snow cover throughout the entire winter in northern Maine. No yields were taken on these trials but stand and disease notes were taken. The trials were held over to determine survival in the third harvest year (1956).

Stands in a year-old birdsfoot trefoil trial at Orono have thinned a great deal and volunteer clovers were present in much of the area. The broad-leaf varieties had somewhat better stands than the two narrow-leaf varieties.

New trials of single-cut and double-cut red clover varieties, white clover, alsike clover and ryegrass were seeded at Presque Isle in the spring of 1955.

Title: FORAGE PRODUCTION OF NITROGEN-FERTILIZED GRASSES AND LEGUME-GRASS MIXTURES

Leaders: C. S. Brown and P. N. Carpenter

The experiment sown in 1954 (1954 Annual Report, page 29) was harvested in 1955 under a simulated silage-pasture management. The first cutting was made at the heading stage, on June 3 for orchardgrass and on June 23 for timothy and brome grass.

Large increases in dry matter resulted from applied nitrogen. Orchardgrass fertilized with 0, 40, 80, 120, and 200 pounds of nitrogen produced a total of 3270, 4500, 5030, 5870, 7000 pounds dry matter per acre. The yields of brome grass and timothy were similar to those of orchardgrass at the higher nitrogen levels, but much more of the total occurred in the first cutting. For example, on plots receiving 80 pounds nitrogen in the spring and 40 pounds after the first cut, the aftermath yields of orchardgrass, timothy, and brome grass were 1820, 1100, and 1040 pounds, respectively.

Yields of the Ladino-grass plots averaged 55% lower than of the grasses fertilized with 120 pounds of nitrogen.

Title: MOLYBDENUM FERTILIZATION OF ALFALFA

Leader: C. S. Brown:

A greenhouse study to determine the response of alfalfa to applied molybdenum on several Maine soils was carried out in 1954-55. Nine soils of diverse origin were cropped with Narragansett alfalfa at low and high lime levels without Mo, and at low lime with added Mo. Total Mo content of the soils ranged from 0.4 to 1.60 ppm, averaging 0.8 ppm.

Significant increases in dry matter yields over the low lime treatment were obtained through the use of Mo on three of the nine soils -- Suffield, Bangor, and Caribou. Small numerical increases occurred on two additional soils. The largest increases were obtained on the Caribou soil in the third and fourth cuttings, 27 and 25%, respectively. High lime was significantly better than low lime plus Mo in all cases.

A second greenhouse study is now in progress with the Caribou and Bangor soils, using four lime levels, with and without added Mo.

Title: GRASS SILAGE PRESERVATION

Leaders: H. C. Dickey and B. E. Plummer

A study comparing wilted silage and bisulfite-treated silage was begun in 1954. Two small experimental silos were each filled with 7 tons of forage containing 15% clover and 85% grass. One silo was filled with wilted forage; the other received unwilted forage treated with 8 pounds of sodium metabisulfite per ton.

Input-output data showed that the wilted silage had the following total losses within the silo: dry matter 26%, protein 28%, carotene 77%, nitrogen-free extract 32%. Losses in the bisulfite silage were: dry matter 14%, protein 22%, carotene 50%, nitrogen-free extract 17%.

No differences in feeding value per pound of dry matter consumed were observed between the two silages. However, heifers consumed approximately 10% more dry matter from the wilted silage and increased body weight gains by about 10%.

MARYLAND

Title: VARIETY AND STRAIN TESTING OF FORAGE LEGUMES AND GRASSES

Leaders: T. S. Ronningen and A. Morris Decker, Jr.

Alfalfa: Williamsburg and Narragansett continued to show superiority in older stands. DuPuits and other similar types, which have been superior in yield the first harvest-year, were about equal to Williamsburg and Narragansett in the second year. Vernal has been included in all trials established in the last two years.

Red Clover: Stevens and Reinholdt, two local farmer strains, continue to be outstanding in all variety trials throughout the state. The performance of Pennscott is as good or better than Kenland in central and western Maryland and was decidedly superior to Kenland in the eastern part of the state, being only slightly inferior to locally adapted strains. Several sources of Kenland seed tested showed very little difference in performance. A new local strain from Cecil County looks promising for the Eastern Shore of Maryland.

Orchardgrass and Tall Fescue: Yields of Alta and Kentucky 31 tall fescue growing with Ladino clover were very similar but were superior to all orchardgrass entries in the trial. Potomac produced superior aftermath growth and higher yields than Commercial orchardgrass on the Eastern Shore. Pasture Lab. Syn. 4 was equal to Potomac in yields while later maturing synthetics were lower in production.

Sudangrass and Pearl Millet: Hybrid #1 pearl millet was very promising in plots cut at a silage stage of growth. This entry was leafy, highly productive and quite free of foliar diseases at harvest time. Common pearl millet produced high yields, but it showed more lodging and amounts of foliar disease than Hybrid #1. Starr pearl millet, which was later in maturity, was low in silage yields. Tift Sudangrass produced lower yields than common or Hybrid #1 pearl millet. Sweet and common Sudan showed considerable leaf disease at harvest. Hurricane damage prevented taking yields at two locations on the Eastern Shore.

Bermudagrass: In observational trials at two locations in the state, Coastal Bermudagrass stands were reduced by winter-killing. This reduction was nearly complete at the College Park location but was much less in Southern Maryland. The Midland strain came through very nicely at these locations. A more extensive testing program is now being undertaken. It will include more entries and will sample a larger portion of the potential Bermudagrass growing area of the state.

Title: EVALUATION OF GRASS SPECIES AND STRAINS FOR USE WITH ALFALFA FOR HAY

Leader: T. S. Ronningen

This trial (1954 Annual Report, page 33) was completed in 1955. Over the 3-year period of the trial all grass-alfalfa combinations exceeded alfalfa alone in yield except for timothy and alfalfa. Commercial tall oatgrass and alfalfa produced the highest yields, but the association contained over 50% grass. Early maturing orchardgrass varieties and synthetics with alfalfa produced almost as much total forage, and those plots contained about 45% grass. Late maturing orchardgrasses though much lower in yields than early maturing types when grown alone were not more than 5% less in mixture yields and contained about 35% grass resulting in a higher quality forage. Yields of smooth brome grass and alfalfa were lower, and proportions of grass averaged about 20%. Timothy averaged about 12% of the total yields of that grass and alfalfa.

Aftermath production of entries of smooth brome grass and especially of timothy was low. Tualatin and commercial tall oatgrass lodged badly at the first harvest in most years when grown alone, and commercial tall oatgrass was badly infested with rust near the end of each growing season.

Title: LADINO CLOVER BREEDING

Leader: T. S. Ronningen

Many of the 98 replicated clones were eliminated over the winter of 1954-55 (1954 Annual Report, page 31). A few of the clones which survived well will be progeny tested as soon as sufficient polycross seed can be obtained. Performance of the better clones with regard to winter survival was similar in another more restricted clonal nursery established in the spring of 1954. A number of the better clones which have become infected with virus will not be further evaluated.

The nursery containing 120 clones from the Pasture Laboratory was discontinued due to large losses of plants during the winter. Some better appearing clones were moved to another nursery.

A screen-house containing two ground beds which can be sub-irrigated is almost completed. It is planned to use this installation to obtain polycross seed from clones of interest to the Northeastern region for progeny evaluation under NE-28. In the future it will be used for obtaining seed where isolation is imperative in red clover as well as Ladino clover breeding.

Title: IMPROVEMENT OF RED CLOVER ADAPTED TO MARYLAND

Leader: A. Morris Decker, Jr.

Seed from 9 related lines (1954 Annual Report, page 31) which have been subjected to repeated seedling inoculation of southern anthracnose (Colletotricum trifolii) and which show a high degree of perennialism will be increased for further testing. Crosses will be made between these lines and superior local strains. Several new local farmer strains have been collected and will be evaluated for yield and other agronomic factors at different locations throughout the state. Strains showing promise will be incorporated into the breeding program.

Title: ORCHARDGRASS BREEDING

Leader: T. S. Ronningen

The 1952 polycross progeny test (1954 Annual Report, page 30) containing primarily progenies of clones from the Pasture Laboratory and the Plant Industry Station, Beltsville, Maryland, was continued. It is planned to submit several of the Beltsville clones for inclusion in the Northeastern regional testing program, NE-28 based on combined data obtained on the clones and their polycross progenies at Beltsville and at College Park.

A new source nursery containing approximately 3,000 spaced plant progenies was established in 1954. The plants consisted mostly of polycross progenies of superior clones. Superior surviving plants from the 1953 nursery were also included in this planting. Wide differences in rust susceptibility were noted in the late summer of 1955.

The tests of varieties and experimental synthetics in several locations in the state were continued and one new trial was established.

Title: TALL FESCUE MANAGEMENT

Leaders: A. Morris Decker, Jr. and Uno Teemant

A management study on Kentucky 31 fescue was completed during the 1955 growing season. Differential clipping treatments (1953 Annual Report, page 30) were ended in the fall of 1954 with uniform harvests being made in 1955 in order to measure residual treatment effects.

Frequency of harvest was most effective in determining total yield, distribution of production, grass-legume balance, persistence of stands and quality of forage produced. Height of cutting was next in importance and affected primarily total yield, grass-legume balance and persistence of stands, but had little effect on the quality or distribution of forage. Highest yields were obtained from tall fescue plus commercial nitrogen followed by tall fescue-alfalfa-Ladino clover, tall fescue-alfalfa and then tall fescue-Ladino clover. Stands of Ladino clover were essentially eliminated when only 3 harvests were made while fair stands were maintained when clipping was more frequent. Close clipping reduced tall fescue stands particularly when alfalfa was included in the mixture. However, the relative performance of alfalfa and Ladino clover was good under this treatment. Frequent clipping substantially reduced alfalfa stands but tended to increase those of Ladino clover. Tall fescue was affected much less by height or frequency of harvest when grown alone and nitrated than when grown with either alfalfa or Ladino clover.

Title: NITROGEN FERTILIZATION ON PURE GRASS AND GRASS-LEGUME ASSOCIATIONS

Leader: A. Morris Decker, Jr.

A study involving 5 pasture grasses grown alone and with a legume under 2 levels of nitrogen (1953 Annual Report, page 31 and 1954 Annual Report, page 35) was terminated since the legume stand had been completely lost by late 1954. No nitrogen was applied in 1955. However, yields were taken in order to measure residual nitrogen effects. In addition, an attempt was made to reestablish clover in the various grasses by making a uniform seeding over the area. Part of the area was disked, part was disked and then cultipacked and part was left undisturbed. Half of each of these areas was clipped frequently while the remainder was allowed to reach a height of 18-20 inches before being harvested. Yields were highest where the plots included a clover the previous year and where nitrogen had been

added. Next highest yields were obtained from the grass plus nitrogen plots followed by the grass-clover mixtures and finally the grass grown alone with no commercial nitrogen. First harvest yields in 1955 ranged from 1.21-.05 tons per acre. The amount of clover reestablishment was inversely related to the spring forage production and was not related to seeding method or clipping frequency. Excellent clover stands were obtained where grass competition was small in the spring while no clover was established where the grasses were vigorous and produced high yields. Each of the 5 grasses behaved differently. Similar studies are being initiated involving additional grass species and nitrogen levels.

Title: FERTILIZATION OF PERMANENT BLUEGRASS PASTURES

Leaders: A. Morris Decker, Jr. and Mitchell Thompson

This study, as set up in 1952 (1952 Annual Report, page 40) was terminated in the summer of 1955 after 2 harvests were made to obtain a measure of residual nitrogen effects. No nitrogen was applied to the test plots in 1955. Yields, as affected by nitrogen carry-over were substantially higher on those treatments which received 3-5 applications each year. This effect decreased until no measurable response could be detected where only 1 early spring application was made. The treatment which produced the most economical returns over a 3-year period appeared to be where 160 pounds of nitrogen were applied in 4 split applications.

Title: GRASS AND LEGUME COMBINATIONS FOR BEEF PRODUCTION

Leader: A. Morris Decker, Jr.

New seedings of Kentucky bluegrass-timothy-white clover, orchardgrass-Ladino clover-red clover, reed canarygrass-Ladino clover-red clover and Midland Bermudagrass-crimson clover were made in the spring and summer of 1955. Each mixture was seeded to 4 half-acre paddocks in each of 2 replications. Additional "stand-by" paddocks of each mixture were seeded to take care of excess animal units during the trial. Yearling Hereford steers will be used as test animals in grazing trials which will begin in the spring of 1956.

NEW HAMPSHIRE

Title: BREEDING OF SMOOTH BROMEGRASS, LADINO AND RED CLOVER

Leaders: G. M. Dunn and L. J. Higgins

Additional work was done during 1954-55 in greenhouse and field inoculations of brome grass with Pyrenophora bromi. Brome grass clones were easier to infect in the greenhouse than seedling progenies. Significant correlations were obtained between clones and their open-pollinated progenies in greenhouse reaction to P. bromi.

Although natural infection was relatively heavy in some nurseries during 1953 and 1954, selection for resistance was not effective without artificial inoculation. Ninety-seven selections were made from nurseries established in 1952 and 1953 (1953 Annual Report, page 36). These plants were placed in a polycross nursery with 3 single clonal replications in the spring of 1955. Two replications were inoculated with infected leaves in August, 1955, and scored in October (1954 Annual Report, page 42). Plants were scored on a 1 (resistant) to 5 (susceptible) basis. Fifty-two of these selections were quite susceptible when inoculated in this manner. The average score of all selections was 3.4 for both inoculated replications, but was only 2.4 for the check replication. Differences between blocks and selections were highly significant. A highly significant correlation (+0.72) was obtained between the leaf spot scores in the two inoculated replications. A number of inbred and open-pollinated progenies were established in the field in 1955. It is planned to inoculate the entire nursery with infected leaves in 1956 to compare selection for resistance to P. bromi in inbred and open-pollinated lines from the same clone. Limited trials were conducted with inbreds in the greenhouse, but results were inconclusive.

Approximately 100 single crosses of brome grass were attempted in the greenhouse during 1954-55. The female plants were emasculated with hot water, and detached male inflorescences were then enclosed in a bag with three or four female heads. The amount of crossed seed obtained by this method was relatively small. During 1955-56, another method will be tried for obtaining single crosses in the greenhouse. Several groups of brome grass plants will be placed on a long-day photoperiod at 2-week intervals. All female plants will be emasculated with hot water. The pollen source will be several clones of an unemasculated selection. It is hoped that single cross seed will be obtained on the female plants following open-pollination.

In Ladino breeding, winter survival notes were obtained in 1955 on nurseries established in 1953. Eighty selections were transferred to a poly-cross block for seed production. Limited seed obtained in this nursery in 1955 will be used to establish new breeding nurseries in 1956.

Morphological and physiological studies on diverse white clover strains which were begun in the greenhouse during the winter were continued in the field in 1955.

In the greenhouse during the winter, red clover breeder's seed was obtained from one-two-three- and four-year old plants which have been maintained in individual pots. In the late summer, a harvest of seed was made from the small increase plot seeded in 1954.

Title: WATER AND FERTILIZER REQUIREMENTS OF SELECTED CROPS AND
SOILS AS RELATED TO SUPPLEMENTAL IRRIGATION

Leader: Allan B. Prince

A study was initiated in the summer of 1955 to determine the effect and interactions of rates of irrigation and rates of fertilization required for economic production of forage crops. A mixture of Fisher brome grass and Pilgrim Ladino clover will receive top-dressings of potash at rates of 160 and 240 pounds per acre and magnesium at rates of check, 40, 80 and 160 pounds of MgO per acre in split application at two levels of supplemental irrigation. A pure stand of Fisher brome grass will receive the following top-dressings of N in split application at 2 levels of supplemental irrigation: check, 80, 160, 200 pounds per acre. Dry weight yields and analysis of plant and soil samples for protein and mineral content will be determined.

In addition to the above experiments, movement of fertilizer in soils as affected by soil type and frequency of rainfall will be studied, using lysimeters housed in a growth chamber where constant light, humidity, soil and air temperatures can be maintained. Brome grass and Ladino clover will be used as test crops.

Title: THE INFLUENCE OF THE LEVEL OF AVAILABLE POTASH IN THE SOIL ON THE LONGEVITY OR PERSISTENCE OF LADINO CLOVER IN HAY STANDS

Leader: Ford S. Prince

These plots (1954 Annual Report, page 44) were continued in 1955 by top-dressing in the spring and harvesting twice during the season. The winter of 1954-55 was destructive to clover stands in the area and very little clover was present in any plot series regardless of treatment. The persistent clover was more prevalent in the plots getting abundant potash without nitrogen although the percentage of clover amounted to only about 2.5% of the total forage. Plots which had no potash, only superphosphate, yielded at about half the rate of the potash treated plots. There was no clover in the plots in the 1955 harvests which had received nitrogen although the yield was slightly greater. Boron appeared to depress hay yields in 1955.

Title: THE EFFECTS OF HEAVY FERTILIZATION OF THE SOIL ON THE MINERAL CONTENT OF FORAGE AND THE EFFECTS OF FEEDING SUCH FORAGES TO DAIRY CATTLE

Leaders: H. A. Keener, F. E. Allen, H. A. Davis, K. S. Morrow and G. P. Percival with cooperation of K. C. Beeson and E. J. Thacker, U. S. Plant, Soil and Nutrition Laboratory, Ithaca, N. Y., and K. McEntee and K. Jubb, Cornell Veterinary College, Ithaca, N. Y.

The work reported previously (1954 Annual Report, page 45) is being continued. Work with calves indicates that some organic factor required for growth and probably lactation is lacking in the heavily fertilized timothy. It is not clear now as to how much of the goiter produced in the animals is due to simple iodine deficiency and how much is due to other factors. The work on the possible deleterious effects of Ladino clover on conception is being expanded. More work is needed to determine the importance of the various mineral deficiencies produced.

Title: MAXIMUM USE OF SILAGE IN FEEDING DAIRY CATTLE

Leaders: H. A. Keener and N. F. Colovos

A study was started in the spring of 1953 to determine the value of corn silage and/or hay in supplementing grass silage as a feed for dairy cattle. Twelve Holstein and 12 Guernsey cattle were started on the experiment at a few days of age and were fed 25 lbs. of milk replacement, 200 lbs. of dry calf starter and 300 lbs. dairy ration. No additional grain is being fed until the animals have calved and milked 5 months. Starting at a few days of age, one-fourth of the animals were given grass silage as the only forage, another fourth received grass silage and limited hay, another fourth received grass silage and corn silage and the final fourth received grass silage, corn silage and limited hay.

All of the animals have been on experiment for over 2 years and several have been in production for 3-6 months. In general, it can be concluded that the feeding of a limited amount of hay along with either grass silage or grass silage and corn silage increased the rate of growth. The feeding of corn silage along with grass silage or grass silage and limited hay decreased the rate of growth. These results can be explained on the basis of nutrient consumption. It appears that the milk production of the animals fed the different forage combinations will be in agreement with growth rates.

Title: THE EFFECT ON THE CAROTENE CONTENT OF GRASSES AND LEGUMES OF VARIOUS METHODS OF PRESERVATIVES

Leaders: G. P. Percival and D. Josselyn

An unwilted grass was put up in 55-gallon oil drum silos (1954 Annual Report, page 46). Treatments included an untreated forage with a moisture content of 80%, dry hay added to reduce the moisture content to 65%, dry hay added to reduce the moisture content to 72%, and sodium meta bisulfite. Judged on a basis of color and odor, the sample with 72% moisture rated first and the untreated the poorest. The silage containing 65% moisture and the meta bisulfite-treated both made good products, but some judges objected to the odor of the meta bisulfite-treated silage. Both of the silages treated with hay showed a greater loss of carotene than the unpreserved silage and this difference could not be explained on the basis of the diluting effect of the dry hay.

Title: THE EFFECT OF SOIL TYPE AND MINERAL ADDITIONS ON THE MINERAL CONTENT OF TIMOTHY AND CLOVER

Leaders: G. P. Percival and D. Josselyn with the cooperation of K. C. Beeson, U. S. Plant, Soil and Nutrition Laboratory, Ithaca, N. Y.

The application of five pounds of cobalt (as the sulfate) per acre by top-dressing plots on a Paxton soil in 1947 was still effective in the spring of 1955 in increasing the cobalt content of forage grown on the plots. Timothy on these plots contained about three times as much cobalt as that grown on the untreated plots, while alsike clover contained about two and one-half times as much cobalt as that grown on untreated plots.

Title: COOPERATIVE REGIONAL RESEARCH ON WHITE CLOVER (LADINO)

Leaders: G. M. Dunn, R. A. Kilpatrick and E. A. Hollowell

This project was recently inaugurated as a cooperative project between the New Hampshire Agricultural Experiment Station and the Forage and Range Section - F.C.R.B.-A.R.S.

Research on the improvement of white clover (principally Ladino) was initiated during the summer of 1955. While the center for the work is located at Durham, New Hampshire, informal cooperation with the other states in the northeastern region is planned.

The objective of this research is to determine factors which are responsible for lack of persistency and low yields of Ladino clover and to develop disease resistant persistent varieties adapted to the conditions of the northeastern states. The genetic, breeding, and pathological phases of the problem have been started. Physiological research will be added as soon as funds become available.

The New Hampshire Station is enlarging greenhouse facilities and adding controlled growth and freezing rooms to accommodate the work.

NEW JERSEY

Title: BREEDING PRODUCTIVE, WILT RESISTANT ALFALFA VARIETIES ADAPTED TO HUMID EASTERN CONDITIONS

Leaders: W. R. Battle, C. R. Skogley, W. Jurgelsky, Jr.

This report covers the calendar year 1955. For earlier activities, see 1954 Annual Report, page 47.

Atlantic Breeder's Seed Fields: Not harvested for seed in 1955, since an adequate reserve of seed is on hand for current activities. Future seed harvests will be made as they are needed to replenish the reserve supply.

1952 Seed Source Test: 110 seed lots of Atlantic, Buffalo and Ranger alfalfa arranged in 4 replications of 6 x 20 ft. plots. Excellent stands have been maintained through the third harvest year. As in the past, no clear cut differences between generations or seed sources were found for persistence, spring growth, fall growth, recovery after harvest, maturity, insect reaction or disease reaction. Next season should be critical from the standpoint of persistence, and the plantings will be observed closely.

1953 Alfalfa Quality Test: 30 alfalfa clones arranged in 3 replications of 3 plants each. Significant differences between clones were found for yield, leafiness, date of maturity, protein and carotene content. Inbred and polycrossed seed was harvested for studies of parent-progeny relationships.

1953, 1954 Alfalfa Variety Tests: 15 varieties replicated 3 or 6 times at 3 locations in northern, central and southern New Jersey. DuPuits, Socheville, Atlantic, Vernal, Narragansett and Williamsburg were highest yielding in that order, as an average of all locations. Yields for these 6 varieties ranged from 4.56 to 4.21 tons per acre, differences among them being non-significant.

Title: HIGH N AND K FERTILIZATION OF ALFALFA

Leader: E. R. Purvis

For the third year, application of nitrogen at the rate of 200 pounds to the acre to a straight stand of Atlantic alfalfa has increased both dry weight and protein yield when crop is harvested in pre-bloom stage. Response disappears if harvest is delayed to 1/10 bloom stage. For first time in study, 300 pounds to acre of K_2O increased yield over 200-pound K_2O application. After 3 years the N plots contain more volunteer grass than plots not receiving N but alfalfa stand is not yet seriously affected.

Title: EFFECT OF PLANT FOOD COMBINATIONS ON ALFALFA

Leaders: J. L. Gerwig and G. H. Ahlgren

This study was started in 1952 (1952 Annual Report, page 52) and summarized each succeeding year. (1953 Annual Report, page 43 and 1954 Annual Report, page 49). This was the first season that nitrogen had a detrimental effect on yield and persistence. Yields on high nitrogen plots were approximately 1 ton less per acre than those receiving no nitrogen and the number of plants per square foot was significantly lower on the high nitrogen plots. However, the percent nitrogen in the plant tissue was significantly higher with the high nitrogen rates than those receiving little or no nitrogen.

Phosphorus applications have not given a significant increase in yield over the 3-year period nor has there been any effect on persistence. However, there was a significant increase in percent phosphorus in the plant tissue with the extremely high rate of 400 pounds of P_2O_5 per acre.

As in the past 2 years, potash was again the most important factor in yield and persistence. With potash as the only variable, yields increased by 2-1/4 tons with high potash fertilization. However, 200 pounds of K_2O were sufficient with higher treatments giving no significant increase in yield.

When the study was initiated there were approximately 10 plants per square foot over the entire experimental area. At the end of the third growing season only one stunted plant per square foot remains on those plots receiving no potash and approximately 6 healthy plants remain where sufficient potash was applied.

The percent potash in the plant tissue varies from approximately 1% where no potash was applied up to 2.5% at the highest rate. Each increment of potash applied brought about an increase in the amount present in the plant.

A new study concerned with the effect of magnesium applied to high potash treated plots has been carried on for two seasons. This study was initiated with the theory that perhaps magnesium becomes a limiting factor when an abundance of potassium is present. Therefore if magnesium were made more available to the plant in the form of $MgSO_4$ then yields might be increased. However, two seasons' data show no increase in yield and no increase in the amount of magnesium present in the plant tissue even though magnesium was applied each year.

Title: EFFECT OF TIME OF FERTILIZING ALFALFA

Leaders: J. L. Gerwig and G. H. Ahlgren

This study was initiated in 1952 (1952 Annual Report, page 52) and summarized each succeeding year. (1953 Annual Report, page 41 and 1954 Annual Report, page 48). The third season's yield data showed no significant differences in total yield due to treatments, except for the check and 1 treatment which was significantly lower at the 5% level. This was in accord with last year's data which showed no significant differences in any treatment except the check.

There has been some interest in trying to increase second and third cuttings by application of fertilizer at different times. However, no significant differences were found between second cuttings or third cuttings due to treatments in the last two years of the study. There has been a significant difference in yield of first cutting due to treatments each of the three years.

In general the first cutting was highest in potassium and phosphorus; and nitrogen, calcium and magnesium highest in the third cutting, with the latter two being negatively correlated with potassium.

No difference in persistence or botanical composition was found due to treatment.

Title: EFFECT OF PLANT FOOD COMBINATIONS ON BIRDSFOOT TREFOIL

Leaders: J. L. Gerwig and G. H. Ahlgren

This study was started in 1952 (1952 Annual Report, page 53) and summarized each succeeding year. (1953 Annual Report, page 45 and 1954 Annual Report, page 50). The third season's data showed a significant decrease in yield due to nitrogen when the birdsfoot trefoil component alone was analyzed. However, no difference in total yield was found. Nitrogen had a detrimental effect on persistence and caused a reduction of approximately 75% of the birdsfoot stand. Clones receiving no nitrogen averaged approximately 4 plants per square foot and those receiving high nitrogen fertilizer averaged only 1 plant per square foot. The percent nitrogen in the plant tissue did not increase with the high rates of nitrogen fertilizer.

Phosphorus application did not give a significant increase in yield in the past two seasons. This year a significant decrease in yield was found when the birdsfoot component alone was analyzed as well as a significant decrease in plants per square foot. A significant increase in percent phosphorus in the plant tissue was found with each succeeding increment of phosphorus.

As in the past two years, potash was an important factor in yield and persistence. This year it was effective in maintaining the stand and gave a significant increase in yield. However, the increase in yield was not as great as had been in the past two seasons. The percent potassium in the plant tissue was found to vary from approximately 1.5% where no potash was applied to 3.5% at the highest rate. Each increment of potash applied brought about an increase in the amount present in the plant.

It is interesting to note that birdsfoot trefoil has the ability to extract potassium, and yield well, at low levels on which alfalfa cannot survive. It is noted too that at high levels the birdsfoot is a more luxurious consumer of potassium than is alfalfa.

Title: EFFECT OF TIME OF FERTILIZING BIRDSFOOT TREFOIL

Leaders: J. L. Gerwig and G. H. Ahlgren

This study was initiated in 1952 (1952 Annual Report, page 53) and summarized each succeeding year. (1953 Annual Report, page 44 and 1954 Annual Report, page 49). The third season's yield data showed no significant difference in time of fertilizer application, the check treatment giving similar yield to that of the other treatments.

This was the first year that there was a significant difference in botanical composition due to treatments. The best stand of birdsfoot trefoil was found on plots receiving no fertilizer and the poorest stand on plots receiving the entire application of fertilizer in the spring before growth started. There was a reduction in stand of the birdsfoot component on the fertilized plots by approximately 20%. In general, the first cutting showed highest percentages of potassium and lowest in magnesium. The third cutting was highest in nitrogen, phosphorus, and calcium with calcium and magnesium being negatively correlated with potassium.

Title: PASTURE RENOVATION STUDIES

Leaders: M. A. Sprague, R. J. Aldrich and A. H. Kates

A continuation of pasture renovation studies during 1955 gave emphasis to (1) chemicals and combinations required for effective kills of old sods, (2) retention of the chemicals in the soil and dead plant materials, and (3) application of renovation techniques to the planting of annual species in the rotation such as Sudangrass and winter grains.

Of the several herbicides tested, Dalapon at 7-8 pounds per acre gave good control of sod grasses but presented serious broad leaf weed problems. Amizole at 4-6 pounds per acre gave good control of all species. A less expensive combination of Dalapon at 4 pounds and Amizole at 1 pound on close grazed sod was equally effective.

Greenhouse and field studies indicated that toxic amounts of chemical are retained in both the soil and dead plant material. Field trials under good rainfall conditions on heavy soil indicated safe seeding of forage species 2 weeks after treatment with Dalapon at 4 pounds and Amizole at 1 pound per acre.

Without exception good stands of forage crop seedlings were obtained wherever the competition of old stands was eliminated by killing the sod. It mattered little how the old stand was killed--the important feature was that it be dead. The amount of tillage had little bearing on germination and emergence providing soil seed contact was made. Surface tillage with disk or similar implements lessened the weed problem materially.

Title: HORSE PASTURE RESEARCH

Leaders: H. W. Gausman and R. W. Duell

The summer of 1955 was the first in which results from most of the field experiments reported below were obtained. In many instances these results are considered preliminary and the experiments will be continued, repeated or revised before sufficient data are available to justify specific recommendations based on this work. All differences mentioned below are based on statistical analyses.

Grass-Fertilization Test: Six common forage grasses were studied with respect to their response to 3 levels of fertilization in terms of yield and mineral absorption. Marked differences in yielding ability of the grasses was in accord with their reputation. All grasses responded to increasing fertilizer rates throughout the season following the April application. Timothy was a notable exception. In the first harvest it did not respond to 1,000 pounds of 10-10-10, the highest rate used. Significant differences in protein were found between fertility levels in May and even in September. Analyses for Ca, P and K are not yet complete.

Birdsfoot Trefoil Management Study: Five time-of-clipping treatments at 2 heights of clipping were studied with the objective of determining the effects on yield of forage, protein content and persistence of birdsfoot trefoil. It was found that 3 harvests per year at the 1/10 bloom stage resulted in the highest yields. Furthermore, clipping with the mower set 1 inch from the soil surface resulted in greater yields than clipping at 3 inches. There were no differences in stand count due to the various time-of-clipping treatments. The 1 inch height of clipping resulted in a decrease in the stand of birdsfoot trefoil. An interaction of these 2 factors existed and it is evident that clipping at 20-day intervals at a height of 3 inches was not detrimental to the stand, while clipping at the same intervals at 1 inch depleted the stand severely.

Sudan and Millet Variety Trials: Ten varieties of Sudangrass and 4 varieties of millet were subjected to pasture management (clipped 3 times) and to hay or silage management (clipped 2 times). The millets generally were the high yielders of the first harvests. Marked differences existed between varieties within any harvest, but considering total yields for the season, the differences were reduced. Sudan varieties differed widely in their HCN content and marked differences between varieties of Sudan and millets were also found.

Sudangrass Management Study: Four rates of seeding of Piper Sudangrass (10, 25, 35 and 45 lbs. seed per acre) 3 rates of nitrogen fertilization (1000 lbs. per acre of 0-10-10, 5-10-10, and 10-10-10), and drilled vs. broadcast seed were studied to determine their effects on yield and chemical composition of the forage cut twice at the soft dough stage.

Yields increased with nitrogen fertilization in both cuttings. No difference between broadcasting the seed vs. drilled seed was found. In the first cutting, yield was proportional to the seeding rate, in the second cutting yield was inversely proportional to the seeding rate. No differences in protein content were found from samples taken at the time of the first harvest.

Introduced Species Trials: Plantings of 35 introduced species in replicated rod rows were initiated in central and also in southernmost New Jersey. Yield data show that many of the species of far south origin were prodigious producers during the hot droughty weather when many of our "adapted" species suffered severely. The winter-hardiness of many of these southern species is, of course, questionable. Several wheatgrasses appeared promising for cool season production. None of the legumes tested appeared promising.

Birdsfoot Trefoil Seedling Establishment Program:

1. Marked differences in seedling weights due to various fertilizer and seed placements were observed in field trials. No differences in seedling weights occurred due to inoculation vs. no inoculation, nor to seeding alone vs. seeding with brome, but there were beneficial results from 1 ton of pulverized lime. Yield data the following season after the fall seeding showed no difference due to fertilizer and seed placement, but marked differences due to inoculation and association with brome. In the third harvest there was a yield increase due to lime.

2. The competitive effects of 24 different combinations of grasses and legumes with birdsfoot trefoil are being studied in the field. Stand counts show marked reduction of birdsfoot trefoil when grown with Ladino clover, alfalfa or orchard-plus-bromegrass. Yield data for 3 harvests and protein analyses have not been summarized.

3. A greenhouse study supported field observations that banding a complete fertilizer only $3/4$ inch from the seed decreased the stand of birdsfoot trefoil. Several depths and lateral displacements were tried with fertilizers of different ratios. Nitrogen-containing fertilizers markedly increased the weights of seedling tops and roots.

4. Several ratios and rates of lime were used in another birdsfoot trefoil establishment study. Thus far the only differences appear to be those due to including 250 lbs. of pulverized lime in the fertilizer mixture that was banded beneath the seed. This resulted in decreased seedling growth.

Title: PRESERVATION OF FORAGES IN PLASTIC MATERIALS

Leaders: M. A. Sprague, C. H. Reed, W. L. Larrabee and
W. Hessenthaler

There is a growing need for preserving pasture and hay crops as silage, particularly in small quantities as a means of removing the crop in line with good crop management (1954 Annual Report, page 53).

During 1955, five units of 12-14 tons each and 10 units of from 45-65 tons each plus a number of smaller units were built representing crops including alfalfa and Ladino clover-grass mixtures, oats and peas, Sudan-grass and corn. Methods were developed to build the stack and handle 2 films. Temperatures were observed during and after filling as indication of respiration rates. Detailed chemical analyses are in progress to determine dry matter losses and relative retention of feed nutrients during storage. Some problems were observed with respect to durability of certain plastics at low temperatures.

CORNELL UNIVERSITY (NEW YORK)

Title: BREEDING AND CYTOGENETIC INVESTIGATIONS WITH THE FORAGE PLANTS
OF NEW YORK

Leaders: R. P. Murphy, R. E. Anderson, C. C. Lowe and E. W. Sprague

This report covers the fiscal year 1954-55 (1954 Annual Report, page 57). The breeding and cytogenetic studies are described here separately for each species.

A. Alfalfa

1951 and 1952 Seedling Source Nurseries: These nurseries were observed again in 1954. They contain a number of progenies from hybrids between diploid species of alfalfa as well as source material possessing the creeping-rooted character. Cuttings from desirable clones were put in a new maintenance nursery in 1955.

1951, 1952 and 1953 Maintenance Nurseries: Plant materials are maintained in these nurseries for possible future need as breeding stock by New York or other states. Parental material is held here while progenies are being evaluated. Some of the material in the 1951 and 1952 nurseries was moved into a new maintenance nursery in 1955.

1953 Seedling Source Nursery: A large number of these plants were derived from intercrossing selected clones from the 1950 single cross nursery which showed the creeping-rooted character plus other desirable plant characteristics. The nursery was observed in 1954 and the best plants were intercrossed during the winter 1954-55. These progenies were planted in a new selection nursery in 1955.

Special Studies: Better plants identified from the special nurseries used to study bacterial wilt resistance, leaf-spot resistance, leaf-hopper resistance and beta-carotene content were moved to a maintenance nursery in 1955. The special study of fertility and cytogenetic relationships between diploid alfalfa species was continued. It was concluded, that from a cytological point of view the 3 diploid species (*sativa*, *falcata*, *gaetula*) are variations within one polymorphic species. This was supported by the data on fertility.

B. Red Clover and Ladino Clover

No breeding or cytogenetic work is currently being conducted on these species at this location. Lack of strong perenniality limits their usefulness at present.

C. Birdsfoot Trefoil Interspecific Hybridization

A special study is currently in progress to develop tetraploid types of *Lotus tenuis* and *Lotus uliginosis* which may be hybridized with the tetraploid *Lotus corniculatus*.

D. Alfalfa, Clover and Grass Introduction Nursery

Seed was not obtained in 1954 on the persisting plants from the alfalfa collections. Seed has been harvested from a few grass species which may be of interest to the breeding program. The surviving alfalfa plants were removed to the new maintenance nursery in 1955.

E. Smooth Bromegrass

The 1952 seedling source nursery was studied again in 1954 and promising selections were rechecked on seed production, aftermath and other plant characters. Desirable selections were dug and established in a replicated polycross nursery in 1955. This work represents a second cycle of selection with this species to isolate recombinant types which are superior to the selected parental plants derived from the first round of selection which began in 1946.

F. Timothy and Orchardgrass

Less work has been done with these two grass species than with the brome-grass. Both are valuable hay and pasture grasses for this area and because of a great diversity in plant type offer considerable promise for further breeding and investigation.

A second cycle of selection is planned for these 2 species. New source nurseries were established in 1955.

G. Irradiation Studies

In cooperation with the Brookhaven National Laboratories, seed of several varieties of brome-grass, orchardgrass, timothy, alfalfa and birdsfoot trefoil was treated with different dosages of thermal neutron radiation.

Field plantings of seedlings from the irradiated seed were established in 1954 for the 3 grass species. These will be studied for irradiation effects and for mutant types which have possible breeding potential.

Damping-off destroyed the major portion of the legume seedlings from the treated seed. Surviving plants were intercrossed in the greenhouse and the progeny were placed in the field for study in 1955.

Useful treatment levels have now been established and study will be continued on the treated plants and their progeny.

Title: THE EVALUATION OF FORAGE CROPS VARIETIES AND STRAINS FOR THEIR USE AND ADAPTATION IN THE NORTHEAST. PHASE I - EVALUATION OF FORAGE CROPS VARIETIES AND BREEDING MATERIALS FOR NEW YORK

Leaders: C. C. Lowe, R. P. Murphy, R. E. Anderson and F. C. Bent

This report covers the fiscal year 1954-55 (1954 Annual Report, page 60). The progeny testing of selected plants and other research conducted under this project are reported here separately for each species.

A. Alfalfa

1948 Ranger Increase Study: Yield data were obtained for the sixth successive year and stand counts were made at the conclusion of the growing season. No differences have been found between the different increase generations of Ranger whereas the check plots of other varieties now differ widely in stand and yield.

1952 Seed Source Tests for Ranger, Buffalo and Atlantic: Seed source tests established in 1952 at the Ithaca location were studied in their second harvest year. A good evaluation of yield and stand was obtained. There was no significant variation among seed sources for different generations of the Atlantic and Buffalo varieties. There was significant variation among the seed sources of Ranger in yield and stand. Variation was most conspicuous in the Foundation and Registered classes. There were no consistent differences due to the state of origin where seed was produced. First and second year data were in close agreement which suggest that the differences observed may be due to differences in quality and germination of seed from the different sources.

1951 and 1952 Uniform Advanced Yield Trials: Yield data were again obtained on the 1951 trial. The 1952 test was noted for stand and vigor in the spring and later plowed because of non-uniform stands. Progeny performance of selected clones as determined from the 1951 test will be used to select desirable parental clones for synthetics. These tests are used to screen introduced varieties and experimental synthetics as a preliminary to further testing. Data are reported to the U.S.D.A., Forage and Range Section, Field Crops Research Branch, for distribution to workers in other states.

1951 NE-10 Polycross Progeny Test: This test was planted in 1951 under Objective 2 of Project NE-10. Fourth-year yield data were collected in 1955. Progeny performance data will be used in constructing synthetic varieties and will be made available to other workers in the Northeast Region.

1951 Alfalfa Generation Study: This experiment was studied further in 1954. Yields continue to show that there is little loss in vigor or yield in advanced generations for most experimental synthetics having a rather narrow genetic base. This experiment has been concluded.

1953 Variety and Management Trial: Second year yields have been obtained on a number of two- and four-clone synthetics produced in New York. A few show some promise with regard to yield performance and general appearance.

New Trials: An advanced Uniform Nursery, a large polycross progeny test, and a synthetic variety trial were planted during 1954 in Northern New York for testing experimental strains and breeding materials in a colder and more stringent environment than is present in the Ithaca area.

B. Smooth Bromegrass

1952 Polycross Progeny Test: This test, originally planted under project NE-10, was studied again in 1954, the second harvest year. Information gained will be used to supplement data obtained in the regional testing of many of the same clonal progeny under projects NE-21 and NE-28.

Isolation Plots for Seed Production: First generation seed was harvested from 4 new experimental synthetics. Second generation seed was harvested from row plantings of 2 synthetic varieties. Seven experimental synthetics were evaluated for seed producing ability along with check varieties in a new test planted in 1951.

C. Orchardgrass

Second generation seed was harvested from row plantings of 1 experimental synthetic. This seed will be used for variety yield trials. Eight experimental synthetics were evaluated for seed production in a nursery established in 1953.

D. Timothy

Second generation seed was harvested for 2 late-maturing synthetics of timothy. These 2 experimental strains were also evaluated for seed production along with a number of check varieties in a new nursery planted in 1953.

E. Reed Canarygrass

Four experimental synthetic strains were evaluated for seed production ability in 1954. No progeny testing or experimental synthetic seed increase is currently in progress for this species.

F. Tall Oatgrass

Three experimental synthetics and appropriate check varieties were evaluated for seed production. No progeny testing or seed increase is currently in progress for the species.

G. Clonal Maintenance

The maintenance nursery established in 1953 and containing clonal material of the grass species listed is being continued. Clones are held here while undergoing progeny testing or for possible future use in the breeding program.

Title: STRAIN TESTING AND BREEDING OF FORAGE PLANTS FOR NEW YORK STATE AND VICINITY, WITH SPECIAL EMPHASIS ON PROBLEMS OF PRODUCTION DURING PERIODS OF MIDSUMMER DROUGHT

Leaders: C. C. Lowe, R. E. Anderson, R. P. Murphy, A. A. Johnson, W. C. Johnson, K. F. Schertz and H. A. MacDonald (Agronomy)

This report covers the fiscal year 1954-55 (1954 Annual Report, page 63).

A. Alfalfa

Tests to date have conclusively demonstrated that Narragansett is superior to all other available varieties over wide areas for short term stands. It averages .3 to .4 tons per acre per year more in yield than varieties now being grown. Although the variety lacks bacterial wilt resistance, it has been equal or superior to resistant varieties in many cases even when the disease is present. This is due to excellent stand establishment and high yields in the early harvest years.

The Flemish strains which include DePuits and others offer opportunity for greatly increased hay production in areas where alfalfa can be cut 3 or 4 times a year. The exceptional vigor and recovery after cutting for this type of alfalfa has resulted in increases in yield up to .5 tons per acre per year over other varieties in short rotations and under a 3-cut management system. These varieties have been persisting well despite their non-dormant habit of fall growth.

Vernal, a new variety developed at Wisconsin, is a promising variety and may replace Ranger for long-term stands or where bacterial wilt is a problem.

Ranger, which is now the most prevalent variety grown in the state, persists well, but is slightly lower in yield and somewhat more susceptible to leaf diseases than new varieties now being increased.

Varieties of alfalfa reported to be creeping in growth habit have not demonstrated this habit under test conditions in New York.

B. Red Clover

Pennscott has given a yield performance equal to that of the best native strains and superior to most common lots. Certified seed of this variety will assure New York farmers better performance than can be expected with common seed.

Dollard, a Canadian variety, has given good performance and may give better performance in the more northern areas of the State.

Northern Anthracnose, was more prevalent than usual at Ithaca in 1954 and markedly reduced yield. Dollard and several experimental strains showed the most resistance to this disease.

None of the varieties of red clover tested show any consistent tendency toward greater perenniality.

C. Ladino Clover

Certified seed has shown slightly better average performance than imported lots and uncertified domestic seed.

None of the named varieties or experimental strains have shown any practical differences in persistence.

D. Smooth Bromegrass

Southern-type varieties have given better yield performance than Canadian Commercial. No important differences in performance have been determined among the Southern-type strains.

Some of the experimental strains developed in New York have been superior in total yield and aftermath production over the best Southern-type varieties. New York synthetic B, named Saratoga, has averaged 20-30% better in aftermath production. This increase in aftermath production comes during the critical period for mid-summer grazing.

E. Timothy

Testing strains of different maturity has shown that total yield is closely correlated with maturity. Medium maturity strains which are about 1 week later than Commercial are equal in yield and better in quality than early varieties. Strains 2 weeks later in maturity are often lower yielding but better in quality of hay than early ones. A very late variety, New York synthetic C, named Essex, was released in 1955 for the production of Foundation seed.

F. Orchardgrass

Yields of most experimental orchardgrass varieties are no higher than for common commercial lots. Strains, later in maturity than Common, give promise because they do not require early clipping in pastures, and therefore may result in a greater use of this highly productive species.

G. Reed Canarygrass

Ioreed appears as good or better than any other varieties or synthetics tested to date.

H. Tall Oatgrass

Tualatin is slightly later but equal in yield with commercial. Extreme earliness and seeding difficulties still limit the use of this grass.

Title: BIRDSFOOT TREFOIL CULTURE AND MANAGEMENT FOR HAY, PASTURE AND SILAGE

Leaders: H. A. MacDonald, Eric Comeau and David Evans

All aspects of this investigation previously reported were continued during 1955 (1954 Annual Report, page 65). Primary stress was devoted to seeding establishment, mixture compatibility, and management for hay and pasture. Also under study was the evaluation of plant form or type comparisons for specific uses under different systems of management.

Birdsfoot trefoil was found responding to seeding conditions and treatments in a manner very similar to that of alfalfa. The slow rate of seeding development and response to treatment was in contrast to that of alfalfa and explains to a considerable extent many of the seeding problems with this crop. Of primary importance in birdsfoot trefoil establishment are (1) adequate soil fertility and lime, (2) a sufficiency of soil moisture, (3) a minimum of weed and other plant competition, (4) good growing conditions for ample root storage the first year, and (5) control of injurious insects and disease.

Seed mixtures comprising birdsfoot trefoil and a single associated grass gave the best results in all cases for hay. The addition of a second legume, such as red clover, increased the total yield in the first year but reduced it in the years following. Under pasture management the inclusion of a second legume or grass was less detrimental and in most cases increased the early yield. It must be pointed out, however, that volunteer plants are a major problem in this type of study. Only under conditions of species control or proper evaluation are the results valid.

A two-cut system of management produced the highest yield with greatest species population covered for all types of birdsfoot trefoil. The Empire and narrow leaf Hudson varieties performed best under close clipping or grazing but were lower in yield than the Viking variety or similar types.

Title: BIRDSFOOT TREFOIL SEED PRODUCTION

Leaders: H. A. MacDonald and J. E. Winch

Many phases of the birdsfoot trefoil seed production problem are under study. This remains one of the most critical factors limiting the expanded use of this forage legume. Recent studies indicate the problem of bud-drop to be a combination of several factors including day length, soil moisture and insect damage. Further work is in progress.

Pure plantings of birdsfoot trefoil at a low seeding rate have in all cases given highest seed yields. Association with tall growing grasses, particularly quackgrass (Agropyron repens L.), were particularly harmful. Marked increase in seed set occurred with thin plantings with adequate insect control. Seed shattering was particularly serious during the dry season of 1955. The use of foliage desiccant sprays and direct combine harvest proved to be a desirable but slow practice.

Progress continues in studies relative to the development and control of hard seed in birdsfoot trefoil. The chemical control of grass infestations is approaching a reality.

Title: BIRDSFOOT TREFOIL STRAIN EVALUATION, IMPROVEMENT AND BREEDING

Leaders: H. A. MacDonald and J. B. Smith

A large number of introduced lines and other source material of birdsfoot trefoil was evaluated for character inheritance and type performance. This material will be used in an expanded breeding program. Studies on the inheritance of the factors resulting in the production of hydrocyanic acid are under way. Crosses were made between positive and negative plants for the characters in question. Selections were made of promising plants in regard to bud drop, seed shattering and high forage yield. Two lines showing promise of higher seed yield were isolated for further study. Several lines were evaluated in regional comparisons in cooperation with the other northeastern states.

Title: FACTORS AFFECTING SEEDING ESTABLISHMENT OF FORAGE PLANTS

Leader: H. A. MacDonald

The work under this project as previously reported (1954 Annual Report, page 66) was continued and expanded during 1955. Particular emphasis during the past year was devoted to the influence of soil fertility, fertilizer placement, seed placement, soil moisture conditions, seeding rate, companion crop influence, and weed competition. The test crops most generally used during 1955 were alfalfa, birdsfoot trefoil, timothy and brome grass.

Soil moisture at and following seeding together with available soil fertility and freedom from excessive competition from other plants were demonstrated to be major causes of seeding failure. Precision seed placement in a soil compacted to form a firm seed bed gave superior results. Competition from seeded comparison crops and volunteer weeds was found to be so severe as to limit or completely destroy the more slowly developing forage seedlings. Omission of a comparison crop was effective in improving the seeding except in locations of high native weed flora where dense weeds proved to be more serious as a competitor than the cereal grain crop.

Title: THE EFFECT OF STAGE OF GROWTH UPON THE YIELD, NUTRITIONAL VALUE, AND LONGEVITY OF THE PRINCIPAL FORAGE GRASSES AND LEGUMES

Leader: H. A. MacDonald

Much of the effort of this project during 1955 was confined to assembling the data obtained and the conduct of chemical analysis. Much of this is now being prepared for publication.

The results of this study show the importance of stage of growth and development per se as a controlling factor in the composition of forage plants. This is modified by the leaf stem ratio and at later stages of maturity by secondary or newly developing leaf and bud tissue.

Where persistence was an important factor management practices for the maximum production of high quality forage were found to be primarily a function of growth stage at time of harvest. Any general conclusion regarding proper stage of growth at harvest was found to require great modification due to the local influence of available plant nutrients, moisture, period till cessation of fall growth and prevalence of injurious insects and disease. The complexity of this problem is determined by the number and intensity of a large number of influencing factors. The solution requires much more rigid experimental observation, record and control than has been possible to date.

Title: BIRDSFOOT TREFOIL INVESTIGATIONS

Leader: Robert R. Seaney

This project was recently set up as a cooperative enterprise between the Field Crops Research Branch, A.R.S., U.S.D.A. and the Agricultural Experiment Station of Cornell University.

Numerous clones, varieties, and species of Lotus are being collected for projected genetic and cytogenetic investigations. Studies on interspecific hybridization, self- and cross-incompatibilities, and inheritance of specific characters are being outlined at the present time.

Title: DISEASES OF FORAGE CROPS

Leaders: D. A. Roberts, L. J. Tyler, K. D. Fezer and C. S. Ramamurthi

As determined by recent disease surveys, the most destructive diseases of forage crops in New York are: root rots, Pseudopeziza leafspot, target spot, and northern anthracnose of red clover; Pseudopeziza leafspot, black stem, and bacterial wilt of alfalfa; leafspot and stem canker disease and root rots of birdsfoot trefoil; pepper spot, Cercospora leafspot, and root and stolon rots of white and Ladino clovers; brown spot and leaf scald of bromegrass; eyespot and leaf streak of timothy; scald, purple leafspot, and leaf streak of orchardgrass.

The detached-leaf technique for testing leguminous forage plants for resistance to foliage diseases is being used experimentally, and might prove useful in plant breeding programs.

It was demonstrated in experiments that alfalfa mosaic virus infection reduces cold hardiness of Ladino clover, probably as a result of impaired carbohydrate synthesis and storage in diseased plants.

A leaf rust of orchardgrass occurs commonly in spaced-plant nurseries. The causal agent is indistinguishable from the fungus described as Puccinia dactylidis Gaum.

Title: EFFECTS OF WILTING AND THE ADDITION OF CHOPPED HAY UPON THE STORAGE LOSSES AND FEEDING VALUE OF RED CLOVER-GRASS SILAGE

Leaders: W. K. Kennedy, G. W. Trimberger and L. S. Wittwer

In 1954 and 1955 three 10 x 30 ft. tower silos were filled with a red clover-grass mixture. The treatments were without wilting, wilted, and unwilted with chopped hay added. In 1954 wilting reduced both juice and fermentation losses and resulted in a saving of about 8% of the total dry matter ensiled. All silages were of good quality and readily eaten by dairy cows. Daily consumption, milk production and changes in body weight were not significantly different for cows receiving the different silages. The second year of the study is under way at the present time.

Title: EUROPEAN CHAFER INVESTIGATIONS

Leaders: W. George Evans, H. H. Shorey and George G. Gyrisco

Studies on the biology of the adults and control of the larvae of the European chafer were continued during 1955. By marking large numbers of beetles and releasing them from different points in a field it was found that most of the beetles did not fly to the nearest tree, indicating, in part, that some distance has to be flown before swarming takes place around a tree. Beetles were recovered from distances of 50, 60, 70, 100, 120, 140, 150, 180, 200, 240 and 300 yards from different trees, with the highest recovery of 28% occurring at a distance of 100 yards.

The adults were found to emerge when the light intensity radiating from the ground was between 1- and 4-foot candles. There was no correlation between emergence and such environmental components as temperature, saturation deficit or relative humidity. Chemical analyses of adults were made in order to investigate whether a build-up of body glycogen was also one of the factors causing emergence. But there was no difference in glycogen content of beetles captured just after emergence and beetles captured at dawn. The respiration rates of adults were also measured and no great differences in rates were detected between adults in the evening and adults in the morning.

Preliminary studies concerned with the control of the adults in dieldrin-treated soils were initiated during the 1955 season. These included laboratory and field tests of the effect of entry into treated soils upon the survival, longevity, and reproductive capabilities of the beetles.

Larval control studies mainly involved continued investigations into the methods and timing of application of various formulations and amounts of organic insecticides for control of the larvae in meadows, pastures, and winter wheat.

Vermiculite and attaclay were compared as carriers of aldrin, dieldrin, isodrin, and heptachlor at 2 pounds, and chlordane at 10 pounds of actual toxicant per acre. It was found that the degree of larval control afforded by any of the insecticides impregnated on vermiculite was essentially the same as that given by the same insecticide on attaclay.

In an experiment with minimum amounts of granulated endrin and isodrin, little control was obtained in these early counts when either insecticide was applied to a meadow at rates of 0.125, 0.25, and 0.5 pounds of actual toxicant per acre.

Granulated, emulsion, and dust formulations of dieldrin applied at 2 pounds of actual toxicant per acre applied during the past hot, dry summer had not significantly reduced larval populations 43 days after the date of application. All formulations had given a fair control 100 days after application, and a significantly lower number of larvae was found in the granulated and dust plots than in the emulsion plots.

Two past experiments were resampled to determine the residual effects of several granulated insecticides upon larval populations. Endrin at 0.5, 1, and 2 pounds and dieldrin at 0.5 and 1 pound of actual toxicant per acre gave excellent control of the second generation of larvae. Dieldrin, aldrin and heptachlor at 1 and 2 pounds and toxaphene at 20 pounds per acre gave effective control of the third generation.

Title: INVESTIGATIONS OF INSECTS INJURIOUS TO BIRDSFOOT TREFOIL

Leaders: H. H. Neunzig and George G. Gyrisco

Studies were directed mainly towards a consideration of certain biological aspects of a number of the more important insects injurious to birdsfoot trefoil.

In addition to other information concerning the life history of the seed chalcid, Bruchophagus gibbus (Boh.), it was determined that the majority of these insects developing in birdsfoot trefoil in north central New York, have one complete generation during the growing season, with the partial development of a second generation; the latter generation mature the following spring. A small percentage of the chalcids have two complete generations during the growing season, and a partial third generation.

Investigations were continued to determine the effect of the feeding of meadow spittlebug nymphs, Philaenus leucophthalmus (L.), on birdsfoot trefoil. It was found that, while 5 and 10 meadow spittlebug nymphs per plant affected the weight increase of the plants, the weight increase difference between plants with spittlebugs, and those without the insects, was not statistically significant. Blossom and bud counts indicated that the feeding of the spittlebug may cause a delay in the time of blossoming.

The alfalfa plant bug, Adelphocoris lineolatus (Goeze), in field experiments, demonstrated its capability of producing a dehiscence of trefoil buds as well as a blighting of the buds.

Tortrix pallorana (Hbn.) and Sparganothis sulphurana (F.) were found to be the most abundant leaf rollers on trefoil in 1955. Studies revealed that T. pallorana has 3 complete generations, and S. sulphurana has at least 2 complete generations on birdsfoot trefoil during the growing season in New York.

Title: ALFAIFA SNOUT BEETLE INVESTIGATIONS

Leaders: C. S. Koehler, H. H. Neunzig and George G. Gyrisco

Heptachlor in the bait formulation was used at a rate of 2 ozs. of actual toxicant per acre, replacing sodium fluosilicate as the insecticide in the standard bait.

Baits were tested again without certain constituents in large scale field trials. It was found that 48 hours after application, the bait without flour gave a 91% reduction in adult beetle populations. Baits without sugar reduced the adult population by 75% but after 10 days both types of bait were equally effective. Baits without sugar and flour were not effective.

Title: CLOVER ROOT BORER STUDIES

Leaders: C. S. Koehler, H. H. Neunzig and George G. Gyrisco

During the 1955 season the following materials were applied for the control of the clover root borer:

Dust formulations - heptachlor, aldrin, dieldrin, diazinon
Emulsifiable formulations - aldrin, heptachlor, lindane, endrin
Granulated formulations - aldrin, dieldrin, lindane, isodrin

Concerning dusts, heptachlor applied at 1.0 lb./acre gave significantly better control than aldrin or dieldrin at 1.0 lb./acre. All 3 materials, however, gave control which was significantly different from the untreated check. Diazinon applied at rates of from 0.5 to 1.5 lbs. per acre gave poor control of the borer. However, the diazinon had been stored for 1 year - indicating possible deterioration.

Emulsifiable formulations of endrin and lindane at 1.0 lb./acre gave control of 75 and 80%, respectively. Other emulsifiable materials used gave control of only 65% or lower.

Granular aldrin and dieldrin, both applied at 0.5 and 1.0 lb./acre, gave significantly better control than the check. Isodrin and lindane at 1.0 lb. and lindane at 0.5 lb./acre likewise gave control significantly better than the untreated check.

It was found that root borer damage and disease intensity are rather closely related. Results of this study indicate that insecticides must be applied more than once if plants are to be kept free from borer and disease pathogen infestation.

Hay yield data point out that injury to plants caused by the borer up to the time of first cutting of first harvest year red clover is not sufficient to reduce hay yields taken from infested fields. Early indications point only to any increase in hay yield in the second cutting from applications made for clover root borer control.

PENNSYLVANIA

Title: THE GENETICS AND IMPROVEMENT OF ALFALFA (MEDICAGO SATIVA L.)

Leaders: H. R. Fortmann and R. W. Cleveland

Evaluation of material in uniform nurseries was continued. The broadcast planting of polycross progenies of 6 rhizomatous clones failed. However, spaced-plant plantings were successful and are being observed.

Variety yield trials including Buffalo, Ranger, Atlantic, Vernal, DuPuits, Nomad, Narragansett, Grimm, and A-224 were established at 8 locations in Pennsylvania.

A new project on Evaluation of Alfalfa Crown Rot has been initiated in cooperation with Dr. H. B. Couch of the Department of Botany and Plant Pathology.

DuPuits alfalfa has been added to the list of recommended varieties for Pennsylvania (with the qualification that it is being recommended for extensive trial use).

Results of a thesis investigation by Mr. J. L. Starling on Optimum Plot Size indicated that a harvest area 3 x 17 ft. as currently utilized, is well within the range of optimum plot size for this area.

Title: THE GENETICS AND IMPROVEMENT OF RED CLOVER

Leaders: H. R. Fortmann and R. W. Cleveland

A yield trial including 4 varieties of red clover was established at 8 locations in Pennsylvania during 1955. Harvests of these experimental plots will be taken in the coming season.

An experimental planting for the evaluation of apparently persistent red clover lines selected from a previous disease nursery was made in 1955 (1954 Annual Report, page 73). Other lines selected from the same nursery were planted for evaluation, but the planting was not successful. A repetition of the latter experiment is anticipated in the coming year. Under the NE-9 project a number of local strains of red clover were uncovered and collected from several diverse localities in Pennsylvania during 1955. An experimental planting for the evaluation of these local strains is anticipated for the coming season.

Title: THE GENETICS AND IMPROVEMENT OF BIRDSFOOT TREFOIL

Leaders: H. R. Fortmann and R. W. Cleveland

Performance of Mansfield, Granger, Cascade, Viking, Empire and "Imported" birdsfoot trefoil will be followed at 8 locations in replicated yield trials established in 1955.

Total 1955 yields in 3 cuts from a planting made in 1951 at University Park were as follows:

Viking	2.79	
3 European lots	2.39	
Granger	2.37	
Cascade	1.99	
N. Dakota	1.08	
Empire	.92	L.S.D. (.05) = .31
N.Y. Narrowleaf	.40	
Oregon Narrowleaf	.15	

Clones have been selected and are currently being increased vegetatively for establishing seed production plots of 5 experimental synthetics which have been formulated.

Cooperative regional evaluation of clones and progenies was continued.

Title: THE GENETICS AND IMPROVEMENT OF FORAGE GRASSES

Leaders: H. R. Fortmann and R. W. Cleveland

Primary emphasis in this project is devoted to orchardgrass, brome grass, timothy, and Phalaris species.

Orchardgrass: A number of parent clones, their polycross progenies, as well as experimental synthetics and varieties are being evaluated under the NE-28 project.

Seed was harvested from restricted polycross nurseries of 3 orchardgrass synthetics (Pa. Early Syn. (I), Pa. Medium Syn. (II), and Pa. Late Syn. (III)). The 3 synthetics are being tested widely in the state, and are currently being increased.

Selected clones from an old source and polycross nursery have been evaluated during the past 2 years. The better clones have been used to formulate 5 new experimental synthetic varieties. Restricted polycross seed production nurseries of these synthetics were established in 1955. The first seed harvest is expected in 1956. The synthetics are designated as follows:

Early Maturity

55-E-1

Medium Maturity

55-M-1

Late Maturity

55-L-1

55-L-2

55-L-3

A yield trial including 8 varieties of orchardgrass was established at 8 locations in Pennsylvania during 1955.

Currently a cytological investigation of the chromosomal constitution of orchardgrass clones included in the NE-28 Project is being undertaken.

Bromegrass: A number of parent clones, their polycross progenies, as well as experimental synthetics and varieties are being evaluated in experimental plantings, most of which are under the NE-28 Project.

A yield trial including two varieties of bromegrass was established at 8 locations in Pennsylvania in 1955.

Timothy: A yield trial including 2 varieties of timothy was established at 8 locations in Pennsylvania 1955.

Phalaris Species: Evaluation of Harding grass (Phalaris tuberosa) strains of diverse origin and F₂ material from a hybrid between P. arundinacea and P. tuberosa was continued during 1955. The latter hybrid material was obtained from Dr. R. M. Love of the University of California.

A cytogenetic study of hybrids between P. arundinacea and P. tuberosa is currently being undertaken by Mr. J. L. Starling in his graduate research program. Hybridization between the 2 species is being attempted in the greenhouse this winter.

Title: AN INVESTIGATION OF ALFALFA CROWN ROT

Leaders: H. B. Couch and H. R. Fortmann

A survey of alfalfa growing areas in Pennsylvania has revealed that alfalfa crown rot occurs generally throughout the state, and that in many areas, the disease is a major factor in reduction of yield and in stand depletion. At the present time, 72 isolates from diseased alfalfa crowns collected from around the state are being tested for pathogenicity. In seedling damping-off tests, the following have been found to be pathogenic: Fusarium spp., Rhizoctonia solani, Acrostolagus sp., Colletotrichum trifolii, Alternaria sp., Cephalothecium sp., and Phoma sp. The ability of each of the 72 isolates to incite alfalfa crown rot is being tested.

Title: FORAGE PRODUCTION OF RYE AND ANNUAL WINTER GRASSES

Leader: J. B. Washko

Tetra Petkus and Balbo rye, field brome grass and domestic ryegrass were compared for forage production during the past 3 seasons at State College. Seedlings were made during the last week in August and the first week in September depending upon soil moisture conditions. The rye varieties were seeded at 3 bushels and the grasses at 20 pounds per acre, respectively. Fertilization was with the equivalent of 400 lbs. per acre of a 10-20-20 fertilizer and 50 lbs. of nitrogen in the form of sulphate of ammonia as a spring top-dressing. Three or four forage harvests were made annually; 1 or 2 as fall grazings, depending upon amount of growth and 2 in the spring, the first grazed, the last a silage harvest. Results are presented in the following table and indicate the amount of both fall and spring forage available for grazing and silage making.

Forage Production of Rye and Annual Winter Grasses at State College, 1952-55.

Species	Forage Production-tons of Dry Matter Per Acre					
	<u>1952</u>	<u>1953</u>	<u>1954</u>	<u>1953</u>	<u>1954</u>	<u>1955</u>
		Fall			Spring	
Tetra Petkus rye	.51	.98	.86	3.28	2.81	1.57
Balbo rye	.59	.23	.84	2.85	3.59	1.80
Field Brome grass	.74	.26	.20	2.90	3.74	1.88
Domestic ryegrass	.45	.39	.24	3.20	3.74	**

**Winter-killed

Title: GRAZING NEW STRAINS OF LEGUMES AND GRASSES IN MIXTURES

Leaders: J. B. Washko and P. S. Williams

The following legume-grass mixtures were grazed for the third year in 1955 on one-half acre paddocks, replicated 3 times: Buffalo alfalfa-S37 orchardgrass. Empire birdsfoot trefoil-Tualatin tall oatgrass. Empire birdsfoot trefoil-S37 orchardgrass, Empire birdsfoot trefoil-reed canarygrass, and Empire birdsfoot trefoil-timothy-Kentucky bluegrass. Lower dry matter yields were obtained in 1955 than for other years for all associations except the alfalfa late-orchardgrass. The stand of Tualatin tall oatgrass in particular declined noticeably from the first 2 years of grazing. The dry matter production from these mixtures for the season on an acre basis in tons was: alfalfa-late orchardgrass, 4.88; birdsfoot trefoil-timothy-Kentucky bluegrass 2.59; birdsfoot trefoil-late orchardgrass 2.38; birdsfoot trefoil-reed canarygrass 2.33 and birdsfoot trefoil-tall oatgrass 1.74. The carrying capacity, expressed as cow-days per acre per season for these mixtures in the order previously listed was respectively 387, 259, 228, 283, and 255.

Title: RENOVATION OF UNPRODUCTIVE PASTURES

Leaders: R. S. Leach and J. B. Washko

Forage yields were obtained in 1955 from renovation experiments at State College and Wellsboro. (1954 Annual Report, page 76). Three years' results indicated that complex Ladino clover mixtures containing several of the more temporary species--red clover, alsike clover, alfalfa, perennial ryegrass, or timothy--proved superior to the simple mixtures of Ladino and a single grass species. Mixtures containing alfalfa at State College yielded as high as 3.18 tons of dry forage annually as compared to check plots that yielded only .95 tons per acre. Viking and Empire birdsfoot trefoil were more productive for the 3-year period when seeded with timothy or other single grasses. Red clover seeded with the 2 trefoils caused a marked reduction in yield during the second and third harvest season. In 1955 Empire trefoil and Viking trefoil in association with timothy and red clover yielded 1.94 and 2.76 tons of dry matter respectively at State College. The same associations with timothy alone produced 3.12 and 3.48 tons per acre.

Mixtures of Ladino, red, and alsike clovers and brome grass; and Empire trefoil and timothy showed no significant yield differences when maintained under grazing conditions during the 1954 and 1955 seasons. The multiple-chisel plow, moldboard plow, or disk plow proved superior from a yield standpoint to cutaway disk, sodium TCA, or CMU for initial land preparation when maintained under grazing management. No yield differences were found among fertilizer applications of 200 pounds per acre of superphosphate (20%), 200 pounds per acre of 0-20-20, and 400 pounds of 5-10-10.

Title: METHODS OF PRESERVATION AND THE MEASUREMENT OF THE NUTRITIVE VALUES OF FORAGE CROPS

Leaders: R. L. Cowan, J. W. Bratzler, R. W. Swift and J. B. Washko

Silos filled during the 1954 season (1954 Annual Report, page 78) have been emptied and the contents evaluated as to losses of digestible nutrients during the ensiling process. Results are summarized as follows:

Treatment and Crop	Digestible nutrients recovered per 100 lb. dry matter ensiled		
	Dry matter	Crude protein	Energy
	lb.	lb.	therms
Prebloom alfalfa			
+ bisulfite	64.6	14.6	128.5
no preservative	43.8	12.0	96.7
wilted	48.4	13.7	102.0
1/10 bloom alfalfa			
+ bisulfite	50.6	12.0	101.0
no preservative	44.7	12.2	97.9
wilted - no preservative	50.9	13.2	104.7
+ bisulfite + ground corn cobs	59.8	9.0	116.8
+ bisulfite + dried beet pulp	63.2	10.1	120.0
Full bloom alfalfa			
+ bisulfite	44.6	9.5	87.3
no preservative	39.5	10.0	79.7
wilted	28.9	7.2	56.4
25% bloom alfalfa			
0 lb. bisulfite/ton	41.2	6.3	31.0
5 " " "	54.1	7.4	104.1
8 " " "	50.5	8.5	94.5
12 " " "	47.0	7.3	90.6
16 " " "	51.6	8.3	95.7

During the 1955 season, a trench silo was filled with prebloom first cutting alfalfa. About $2/3$ the length of the trench was treated with bisulfite and the remainder untreated. Approximately half of each portion was covered with an air-tight plastic sheet.

Losses of nutrients from each of the 4 zones will be measured by a bag sampling technique, the validity of which will be checked by means of total loss measurements on 4 x 8 ft. upright silos.

In another experiment eight 4 x 8 ft. steel silos were filled with first cutting alfalfa at 10% bloom stage with the following treatments:

- unwilted with (1) no preservative
- (2) bisulfite
- (3) Kylage (calcium formate-sodium nitrite)
- (4) corn and cob meal
- (5) corn and cob meal + bisulfite

- and wilted with (1) no preservative
- (2) bisulfite
- (3) Kylage

These silos are now being emptied, and losses of nutrients and digestibility are being measured. Digestion trials are also being conducted on samples of the same crop which have been preserved in frozen storage since harvest, fed with and without added corn and cob meal.

Third cutting alfalfa has also been ensiled in four 4 x 8 ft. silos (2 glass-lined, airtight, and 2 ordinary steel) with and without added bisulfite. These silos will be opened after 2 years' storage.

Title: FORAGE INSECTS

Leaders: Norris D. Blackburn and John A. Chemsak

Investigations on forage insects, which were interrupted in 1954, were resumed during the past season. Ecological and insecticidal studies on several forage pests were conducted in the central part of the state, while investigations on the alfalfa weevil, Hypera postica, were initiated in the southern counties.

An experiment, consisting of a series of small (1/100 A.) replicated plots, was designed to obtain data on the influence of insecticides, applied for control of the Meadow spittlebug, on other components of the insect complex associated with alfalfa. Net sampling was employed 40 days after treatment. On the basis of such sampling techniques in small plots where migration was a factor, it was impossible to demonstrate differences in population except among those forms, such as aphids and cicadellids, whose movements are restricted to small areas. Data for these two insect groups are summarized.

Insecticide	Relative abundance of	
	Aphids	Cicadellids
Check (untreated)	1	1
Methoxychlor	2	0.2
Toxaphene	3	0.7
Heptachlor	4	0.7
Dieldrin	7	0.8

There are indications that the alfalfa weevil may become a limiting factor in the production of alfalfa in the state. This insect now occurs in at least 24 counties in the southern and eastern sections with the highest level of injury in York, Lancaster, and parts of Adams county. It was estimated that 60-70% of the first cutting of alfalfa was destroyed in many fields of this area during the past season. At present, there is no evidence to indicate that alfalfa weevil will not spread eventually into all areas of the state where alfalfa is grown.

The peak of egg-laying activity for 1955 occurred during the second week of May in southern Pennsylvania with severe larval injury to the foliage appearing soon thereafter. Adults were present in the fields throughout the summer and early fall, although little damage was observed from their feeding activities. Samples taken at various hours of the day and night during the month of August indicated that these insects, like many other curculionids, may be somewhat nocturnal in their habits.

Caged areas have been established at 2 points in the southern part of the state in an effort to obtain more precise data on the life cycle and behavior patterns under Pennsylvania conditions. Critical evaluations of control measures are planned for 1956.

Title: FEEDING GRASS SILAGE TO DAIRY CALVES

Leaders: G. H. Porter and E. M. Kesler

To study further the value of high quality grass-legume silage as a source of roughage for the young dairy calf, 3 groups of 12 Holstein male calves were assigned to hay, grass silage and hay plus grass silage treatments with starter fed to a 3-pound daily maximum. In an attempt to ascertain the feasibility of feeding grass silage as the sole source of roughage to calves of a smaller breed, 2 groups of 5 Guernsey calves each were fed hay or grass silage as the roughage source. Starter was limited to 3 pounds daily. The duration of both trials was 16 weeks.

Growth response in both experiments was not significantly affected by treatment. However, the total digestible nutrient intake of the grass-silage-fed Holstein calves was significantly ($P < 0.01$) lower than calves fed either hay or hay plus grass silage. As in the original work, (1954 Annual Report, page 79) results reported here suggest the grass-silage-fed calves were able to efficiently utilize the nutrients in silage as indicated by comparable growth response on significantly lower TDN consumption than the hay-fed calves.

With regard to the Guernsey calves, TDN intake and growth response closely paralleled each other, whether fed hay or grass silage as the only roughage.

To date, these studies would appear to warrant the following conclusions:

1. The ad libitum feeding of good quality grass silage as the sole source of roughage to the young Holstein calf during the first 16 weeks of life should result in comparable though slightly lower growth response than when fed either hay or hay and grass silage as the roughage source.
2. Growth performance and TDN consumption will tend to parallel each other during the first 16 weeks of life whether the roughage portion of the calves' ration is hay alone or hay and grass silage fed in combination.
3. When quality grass silage is fed as the sole roughage to Holstein calves, relatively low TDN consumption can be anticipated.
4. Satisfactory growth may be expected when quality grass silage is fed as the sole source of roughage to the young Guernsey calf through 16 weeks of age.

RHODE ISLAND

Title: BREEDING IMPROVED ALFALFA FOR EASTERN UNITED STATES

Leaders: T. E. Odland and R. C. Wakefield

The Breeder's seed plot of Narragansett alfalfa established in 1946 was continued and 5 pounds of seed obtained. Weather conditions were extremely poor for seed production - too much rain at seed setting time. This was by far the lowest yield obtained in any year since this seed plot was established. The Breeder's seed produced on this plot has been used every year for seed increase in the National Foundation Seed Program. A total of 1,500,000 pounds of certified Narragansett alfalfa seed was produced in this program in 1955.

About 2000 cuttings were made from the plants in the Breeder's seed plot the past summer. These are being propagated in the greenhouse and will be used for establishing a new Breeder's seed plot in a more isolated area of the experimental farm. The old plot will then be discontinued.

Data were obtained on the polycross nursery, but no further crosses were made.

Title: SOIL FERTILITY AND SOIL MOISTURE RELATIONS IN GRASSLANDS IN THE NORTHEAST

Leaders: R. C. Wakefield, M. Salomon and C. E. Olney

This test was harvested for the fourth year (1954 Annual Report, page 82) at a single location on the University farm. A similar test at a second location was discontinued. Dry matter yields and botanical composition of the Ladino clover-bromegrass mixture were determined.

Winter damage to stands of clover was widespread. Differences in survival due to fertilizer treatments were not apparent. Recovery of the clover was poor and yields for the year were relatively low.

Response to phosphate was significant at 120 pounds or at a much higher level than during previous years. Response to potash was again greatest at the 120-pound per acre application. Best recovery of Ladino clover from winter injury appeared to be dependent on a substantial phosphate fertilizer application.

Chemical determinations of phosphorus and potassium in the soil and in the forage are being made. Preliminary results indicated that the available phosphorus content in the soil was small at all rates of application. Accumulation of potassium in the soil was shown to be large only at the 240-pound per acre application.

Title: POTASH SOURCES AND RATIOS

Leaders: T. E. Odland, R. C. Wakefield and M. Salomon

Yields and botanical composition of a Ladino clover-bromegrass mixture were determined during the third harvest year. (1954 Annual Report, page 83). Highest yields were obtained with a minimum application of 160 pounds per acre of potash. Decreasing increments of potash generally resulted in lower yields. Plots receiving the higher rates of potash contained more clover and were less weedy. The 0-1-2 fertilizer was superior to other ratios. Plots receiving sulphate of potash gave somewhat higher yields than comparable plots receiving muriate of potash.

Correlation of the plant tissue tests for potash was found to follow potash fertilizer levels very closely.

Title: MYCOTIC FOLIAR DISEASES OF ALFALFA IN RHODE ISLAND AND THEIR CONTROL WITH FUNGICIDES

Leaders: J. Troll and F. L. Howard

During the summer of 1955, an experiment was initiated to determine the approximate date of appearance of different fungi and the extent of injury caused by them to alfalfa foliage. In addition, tests were conducted in which fungicides were sprayed on replicated plots of 6 alfalfa varieties. The spray program was conducted in relation to cutting dates and succession of pathogens. Experiments with fungi-toxic chemicals toward control of these fungi are being currently conducted in vitro in the laboratory and in vivo in the greenhouse.

During the 1956 growing season the succession and relative importance of alfalfa leaf pathogen will be determined further.

Those fungicides that show evidence of best control under laboratory and greenhouse conditions will be used on field plots to determine their efficiency and practicability.

Title: INSECT AND OTHER ALLIED PESTS OF FORAGE CROPS AND THEIR CONTROL
UNDER RHODE ISLAND CONDITIONS

Leaders: T. W. Kerr and C. E. Olney

In surveying the insects attacking alfalfa, it was determined that the pea aphid, Macrosiphum pisi (Kltb.), Lygus lineolaris (P.deB) and several species of leafhoppers were the most abundant species found. Initial studies of pea aphid control on the first crop of alfalfa showed malathion to be the most effective insecticide. Inconclusive results on insect control were obtained with malathion, methoxychlor and DDT on the second crop of alfalfa. Analyses of the first crop sprayed with 2 pounds per acre of actual malathion and methoxychlor showed less than 0.75 p.p.m. of the former insecticide and 19 p.p.m. of the latter (dry weight basis) 25 days after the insecticides were applied.

Title: ZERO PASTURE FEEDING OF DAIRY CATTLE

Leaders: J. Cobble, B. W. Henderson, Jr., and H. Cook

Cooperating Departments: Animal and Dairy Husbandry,
Agricultural Economics, and Agronomy

The objective of this study is to determine the effect on milk production and body weights of dairy cattle and growth of heifers when fed green chopped forage in dry lot as compared to conventional pasturing practices.

In compiling data from two years' work, it was found that the 25 experimental cows and the 25 paired controls did not vary significantly in body weight through the two 16-week trial periods. The grazing animals did show slightly more gains as a group. The average milk production of 4% F.C.M. produced per acre for the soilage group amounted to 5124 pounds. The cows being grazed produced 3747 pounds of milk during the same period on forage from the same plots. The soilage group required 1.4 acres per cow to supply necessary forage, whereas the grazing group utilized 2.2 acres per animal. The "Zero Pasture" group consumed an average of 135 pounds of chopped green forage per day per cow.

Twelve heifers weighing 600-700 pounds were fed chopped green forage over a 115-day period and produced a daily gain of 1.2 pounds. The paired controls gained an average of 1.56 pounds per day per heifer.

Although the data have not been completely analyzed, studies were made on barn feeding of green forage and its relationship to milk production and labor requirements. Also an attempt was made to find the influence of alternating silage feeding with grazing on individual animal production. In this work cows were "zero pastured" for 5 days and for the remaining 2 days they were allowed to graze.

Title: THE VALUE OF GRASS-LEGUME SILAGE AS A SOLE ROUGHAGE FOR
DAIRY CATTLE

Leaders: J. Cobble, B. W. Henderson, Jr. and G. Wildes

Cooperating Department: Agricultural Chemistry

The objectives of this study are: (1) To determine the palatability and consumption of grass-legume silage when fed as the sole roughage to lactating cows. (2) To study effect of grass-silage on milk production and body weight when fed as the sole roughage. (3) To determine the economy and efficiency of raising dairy heifers solely on grass-legume forage.

A double reversal feeding procedure is being used. One group receives all the forage in the form of silage and the paired group receives the roughage in the form of 50% silage and 50% hay. Grain feeding is based upon pounds of 4% fat-corrected milk.

A group of 30 dairy heifers is being maintained on an all grass-legume silage. The silage is being fed from a self-feeding bunker silo and the animals are being housed in a loafing shed. Comparisons of gains, condition, labor costs, etc., are being made in relationship to barn feeding and housing of similar animals.

Title: POULTRY RANGE STUDIES

Leaders: W. H. Wiley, S. B. Smith, W. K. Durfee, L. T. Smith
and R. C. Wakefield

A study to determine the value of range rearing of pullets as measured by laying-house performance was continued during the past year. Treatments consisted of (1) Ladino clover (2) well-fertilized sod - mostly bluegrass (3) unfertilized native sod and (4) confinement. Plots were 1/6 acre in size, replicated 3 times and planted in series for a 3-year rotation. Plots were stocked with 60 pullets each on May 18, 1955. Shelter, water and feed were available at all times.

Growth on range for 1955:

	<u>Confinement</u>	<u>Ladino</u>	<u>Bluegrass</u>	<u>Untreated</u>
Avg. wt. at housing	5.04	4.87	4.84	4.93
Avg. gain on range	2.81	2.64	2.61	2.72
Lbs. feed per lb. gain	7.40	7.70	7.82	7.61

No significant differences in housing weight were found between range treatments. However, confinement reared birds weighed significantly more than did range treatment birds.

Egg production and cost of production analysis will be determined.

VERMONT

Title: EFFECT OF SIMULATED PASTURE MANAGEMENT PRACTICES ON THE PERSISTENCE, QUALITY, AND YIELD OF BIRDSFOOT TREFOIL SPECIES AND VARIETIES

Leaders: K. E. Varney and G. M. Wood

First year yields were taken on 6 trefoil varieties and species managed as "severe" (cut 4 inches back to 1 inch), "rotational" (cut 8 inches back to 2 inches) and "aftermath" (first crop hay, second 8 inches back to 2 inches). The F values for varieties, managements, and the interaction, VxM were all highly significant. The average yields of trefoil for all varieties at the 3 managements were -- Severe 0.95, Rotational 1.24, and Aftermath 1.89. The overall average yields of the varieties were Viking 1.77, Mansfield 1.66, Cascade 1.56, Polyploid Narrow 1.37, Empire 1.29, and Narrowleaf 0.52. The significant interaction appeared to be due largely to the fact that the performance of polyploid narrowleaf in contrast to the other varieties under the "Rotational" management was relatively poor and that Cascade performed relatively better under "Aftermath" management.

Title: TREFOIL VARIETY TRIALS

Leader: Glen M. Wood

Four varieties of trefoil were grown alone and in 2 grass associations at Addison and at Burlington, Vermont, where yields were taken twice annually from 1952-54 and 3 times in 1955. The 4-year average yield at Burlington was -- Mansfield 1.20, Viking 1.14, Granger 0.93, and Empire 0.69. At this location, Empire was significantly lower yielding than the other varieties in the first 3 years, but top yielder at the first harvest in 1955 with 0.32 tons of dry matter per acre. Mansfield gave significantly more yield than Viking in the first harvest year but these varieties performed similarly in subsequent years and for the 4-year average. The plant population, particularly in plots of the 3 European type varieties, was markedly reduced in 1955.

At Addison, the 4-year average yields were -- Mansfield 1.80, Viking 1.65, Granger 1.52, and Empire 1.70 tons of dry matter per acre. In this test, the varieties gave significantly different yields only in 1954 when Mansfield was superior to Granger and Empire, while Viking was superior to Granger.

Title: LADINO CLOVER YIELD TRIALS

Leaders: T. R. Flanagan and A. Gershoy

Studies of the relative yielding ability of Pilgrim, Oregon (F.C. 23924) and polyploid Ladino clover were initiated in 1953. (1954 Annual Report, page 85). In 1955, the second harvest year, 5 cuts were obtained under relatively high moisture and fertility conditions. Additional yield studies will be obtained in 1956 and a more detailed report will be submitted at that time.

Replicated plots of diploid and tetraploid Ladino clover were established in 1955 to evaluate the interrelationships of size and numbers of plant parts on ground cover and subsequent yields with special reference to the effects of seeding rate, fertility and the availability of water to the plants.

WEST VIRGINIA

Title: ALFALFA BREEDING AND GENETIC INVESTIGATIONS

Leader: Dale A. Ray

The alfalfa source nursery consisting of space-planted foreign introductions, persistent local selections and recommended varieties was continued in 1955 for the evaluation of entries for winter recovery, vigor, leafiness, disease and insect resistance and forage yield. Six new collections from persistent alfalfa stands, 1 new variety and 7 foreign introductions were added in replacement of winter-killed or otherwise undesirable entries. It was noted that a high positive association was expressed by the rate of recovery from winter dormancy and the forage yield of the evaluated plants. Single foreign introductions from Peru, Turkey, South Africa and Iran exhibited a moderate tolerance to winter conditions but the remainder of the foreign collections were very sensitive to winter injury and slow in recovery. Spittle bug, leaf spots and black stem were general in incidence but certain introductions from Turkey, Portugal and South Africa were relatively resistant to the leaf diseases. The most outstanding forage yields were obtained from single plants of Narragansett, Rhizoma, Williamsburg and Vernal varieties and of a Medicago falcata collection, which yielded as much as 1 pound or more of dry forage per plant harvested in 3 clippings. Self and cross pollinations are being made in the greenhouse for study of the inheritance of morphological differences in alfalfa and selections are being increased for the establishment of a polycross nursery.

Title: USING NITROGEN FERTILIZER EFFICIENTLY: THE USE OF NITROGEN
ON BLUEGRASS

Leaders: G. G. Pohlman and N. M. Baughman

A test of 4 rates of nitrogen application (0, 120, 240, and 360 lbs. N per acre) at 2 levels of fertility with varying dates of nitrogen application was started in a bluegrass sod in 1954. The grass was harvested with a lawn mower set to cut at 1-1/2 inches. Twelve cuttings were made in 1954 and 14 cuttings were made in 1955. Increases in yield were secured in all cases in 1954 with the application made April 15, giving a greater response than the July 1 application. Some results from the April 15 application at high fertility level are shown below:

Treatment	Yield Dry Matter Lbs. Per Acre	Yield Protein Lbs. Per Acre	% N Recovered In Herbage
None	1017	181	
120# N - April 15	2441	546	48.6
240# N - April 15	3900	865	45.6
360# N - April 15	4736	1155	43.3

In 1955 nitrogen was applied March 1, April 14, June 30, and September 17. The highest total yield was secured on the plots treated April 14. These yields were 2278, 3070, 3990, and 5894 pounds per acre for the 0, 120, 240, and 360-pound application, respectively. Top yield for the March 1 application was 5004 pounds per acre and for the June 30 application the top yield was 4256 pounds per acre. Both of these were for the 360-pound application and were significantly higher than the yields for lower rates of application. The September 17 application was too late to have much effect on total yield. However, it did significantly increase growth during October and early November.

Yield distribution was markedly affected by time of application. The periods of maximum growth in 1955 are shown in the following table:

Time of Application	Date of Maximum Production	Production Per Day Lbs. Per Acre
None	May 20-31	21
March 1 - 360 lbs. N	April 12-22	73
April 14 - 360 lbs. N	May 9-20	64
June 30 - 360 lbs. N	July 15-19	58

These data would seem to indicate that a considerable part of the decline in production associated with hot, dry weather is in reality due to lack of available nitrogen, and that production can be maintained at a high level throughout the normal season by proper timing of nitrogen application.

Title: ALFALFA VARIETIES

Leader: O. J. Burger

Row seedings of the alfalfa varieties Narragansett, Williamsburg, Atlantic, Grimm, Vernal, Rhizoma, Ranger and Buffalo were made in the spring of 1954 to study yield, protein content and seed-yielding ability. Four replications were used.

Narragansett, Atlantic, Vernal and Rhizoma were the highest yielding varieties during the 1955 harvest season. These varieties also produced the greatest total yield of crude protein per acre at the first harvest, 1955.

Narragansett contained the highest percentage of crude protein at the first harvest with 19.2%. This was nearly 2% higher than Grimm and 3% higher than Williamsburg. Protein analyses of the second and third harvests are now being made.

Title: THE INFLUENCE OF FERTILITY AND MANAGEMENT ON SEVERAL LADINO CLOVER-GRASS MIXTURES

Leaders: O. J. Burger, C. Sperow and D. R. Browning

Description of treatments, both fertilizer and management for the years 1952, 1953, and 1954 can be found in 1953 Annual Report, page 79.

Grasses offering the least competition to Ladino clover continue to be smooth brome grass and reed canarygrass. Orchardgrass and Kentucky 31 fescue offered the most. This is supported by the potassium analyses as reported in 1954 Annual Report, page 89. Essentially the same information was found from the chemical analyses made on the 1954 plant material.

Onto the former intermediate and hay management plots several fertilizer treatments varying in amounts of phosphorus and potash were applied. A maximum of 160 pounds of phosphorus and 320 pounds of potash were applied. The Ladino clover-grass mixtures responded mostly to the potash treatment. A 40-50% increase in total forage production was obtained from a treatment of 0-160-160 compared to 0-160-0.

Application of high amounts of potash was conducive to increased Ladino clover fraction in all mixtures.

LIST OF PUBLICATIONS

- Allred, K. R., W. K. Kennedy, L. S. Wittwer, G. W. Trimberger, J. T. Reid and J. K. Loosli. Effects of preservatives upon red clover and grass forage ensiled without wilting. Part I. Storage losses. Cornell Agr. Expt. Sta. Bul. 912. 1955.
- Barnett, F. L. A karyological survey of several *Bromus* species. Agron. Jour. 47: 88-91. 1955.
- Battle, W. R., M. Ribaldi and A. Panella. Avvizzamento batterico dei medicaî italiani. (Bacterial wilt of alfalfa in Italy.) Giornale di Agricoltura LXV: 255. 1955.
- Brewbaker, James L. Incompatibility in autotetraploid white clover. II. Dominance and double reduction. Genetics 40: 137-152. 1955.
- Buller, R. E., J. S. Bubar, H. R. Fortmann and H. L. Carnahan. Effects of nitrogen fertilization and rate and method of seeding on grass seed yields in Pennsylvania. Agron. Jour. 47: 559-563. 1955.
- Carnahan, H. L. and K. G. Brown. Quantitative inheritance in *Trifolium repens*. Agron. Abstracts 1955 Annual Meetings. Amer. Soc. Agron. p. 48.
- _____ and Helen D. Hill. *Lolium perenne* L. X tetraploid *Festuca elatior* L. triploid hybrids and colchicine treatments for inducing autoallohexaploids. Agron. Jour. 47: 258-262. 1955.
- _____, _____, A. A. Hanson, and K. G. Brown. Inheritance and frequencies of leaf markings in white clover. Jour. of Heredity XLVI: 109-114. 1955.
- Cunningham, L. C. and W. W. Peek. Crops and livestock by type of farm in the Central Plain Region, New York. Cornell Univ. Agr. Expt. Sta. A.E. 1005. 1955.
- Dixon, L. V. Economic efficiency in dairy cattle feeding on Connecticut farms. M.S. Thesis. University of Connecticut. 1955.
- Emery, Donald A. Selection in smooth brome grass for resistance to brown leaf spot (*Pyrenophora bromi*). M.S. Thesis. University of New Hampshire. 1955.

- Erbe, L. W. A study of the fertility relationships of Lotus corniculatus, tetraploid L. tenuis and their F₁ hybrid progeny. M.S. Thesis. University of Vermont. 1955.
- Fellows, I. F. Economic application of forage production and utilization research. Jour. of Farm Economics 37(5). 1955.
- Graham, J. H. Helminthosporium leaf streak of timothy. Phytopathology 45: 227-228. 1955.
- _____. A disease of orchardgrass caused by Pleospora phaeocomes. Phytopathology 45: 633-634. 1955.
- Hanson, A. A. and J. H. Graham. A comparison of greenhouse and field inoculations of Ladino clover with Sclerotinia trifoliorum. Agron. Jour. 47: 280-281. 1955.
- Held, Victor M. Physiological differences between a normal and a degenerate strain of Sclerotinia trifoliorum. Phytopathology 45: 39-42. 1955.
- Hill, Helen D. and H. L. Carnahan. Effects of variables in weather and their interactions on metaphase cells in root tips of grasses. Bot. Gaz. 116: 82-86. 1954.
- Hofmann, Ralph H. Evaluation of selected clones of orchardgrass (Dactylis glomerata L.). I. Seedling vigor and yields of polycross progenies in a greenhouse test. II. Field performance of open-pollination progenies and spaced-planted parental clones. M.S. Thesis. The Pennsylvania State University. 1956.
- Jones, R. L. A comparison of three permanent pasture mixtures and three summer forages for maximum beef production. M.S. Thesis. University of Maryland. 1955.
- Jurgelsky, W. Jr. Variation and interrelationship of certain chemical and morphological characters associated with quality in alfalfa. M.S. Thesis. Rutgers University. 1955.
- Keener, H. A., F. E. Allen, H. A. Davis, K. C. Beeson and E. J. Thacker. Trace mineral deficiencies in cattle resulting from heavy fertilization of the soil. Jour. Dairy Sc. 38: 626. 1955.
- Lowe, C. C. and R. P. Murphy. Open-pollinated seed setting among self-sterile clones of smooth brome grass. Agron. Jour. 47: 221-223. 1955.

- Margolf, P. H. and J. B. Washko. Seven years of managed turkey grazing. The Pennsylvania State University College of Agriculture, Agr. Expt. Sta. Bul. 608. 1955.
- Mears, Kathryn A. Studies in species hybridization in the genus *Lotus*. M. S. Thesis. University of Vermont. 1955.
- Oldemeyer, Donald L. and A. A. Hanson. Evaluation of combining ability in orchardgrass, *Dactylis glomerata* L. Agron. Jour. 47: 158-162. 1955.
- Peek, W. W. Forage production and use in the Central Plain Region of New York. Ph.D. Thesis. Cornell University. 1955.
- Roberts, D. A. Use of a detached-leaf technique for testing leguminous forage plants for resistance to foliage diseases. (Abs.) Phytopathology 46: 24. 1956.
- _____. Influence of alfalfa mosaic virus infection upon winter hardiness of Ladino clover. (Abs.) Phytopathology 46: 24. 1956.
- _____. and R. P. Murphy. *Puccinia dactylidis* on orchardgrass in New York. Plant Dis. Reporter 39: 881-882. 1955.
- _____, K. D. Fezer and C. S. Ramamurthi. Diseases of forage crops in New York, 1955. Plant Dis. Reporter 40: (in press).
- _____, R. T. Sherwood, K. D. Fezer and C. S. Ramamurthi. Diseases of forage crops in New York, 1954. Plant Dis. Reporter 39: 316-317. 1955.
- Ronningen, T. S., A. M. Decker, Jr., R. L. Jones and R. E. Foster. Pastures for beef cattle. Maryland Agr. Expt. Sta. Bul. 455. 1955.
- _____. and A. G. Hess. Relationship between stand and yield in alfalfa variety comparisons. Agron. Jour. 47: 92-93. 1955.
- Sprague, V. G. Distribution of atmospheric moisture in the microclimate above a grass sod. Agron. Jour. 47: 551-555. 1955.
- _____, A. V. Havens, A. M. Decker and K. E. Varney. Air temperatures in the microclimate at four latitudes in the Northeastern United States. Agron. Jour. 47: 42-44. 1955.

- Sprague, V. G., Hans Neuberger, W. H. Orgell and A. V. Dodd. Air temperature distribution in the microclimatic layer. Agron. Jour. 46: 105-108. 1954.
- _____, P. S. Williams, C. B. Knodt, E. M. Kesler and A. L. Haskins. Seasonal distribution and production of forage and milk from orchardgrass-Ladino and bluegrass pastures. The Pennsylvania State University College of Agriculture, Agr. Expt. Sta. Bul. 592. 1954.
- Starling, James L. Estimation of optimum size of broadcast plots for forage crop investigations using data from uniformity trials. M.S. Thesis. The Pennsylvania State University. 1955.
- Sullivan, J. T. Cellulose and lignin in forage grasses and their digestion coefficients. Jour. of Animal Sc. 44: 710-717. 1955.
- _____, and D. G. Routley. The relation of the protein content of forage grasses to earliness of flowering. Agron. Jour. 47: 206-207. 1955.
- Teemant, Uno. Tall fescue management. (Festuca elatior var. arundinacea). M.S. Thesis. University of Maryland. 1956.
- Trimberger, G. W., W. K. Kennedy, K. L. Turk, J. K. Loosli, J. T. Reid and S. T. Slack. Effect of curing methods and stage of maturity upon feeding value of roughages. Part I. Same levels of grain. Cornell Agr. Expt. Sta. Bul. 910. 1955.
- Wittwer, L. S., G. W. Trimberger, W. K. Kennedy, K. R. Allred, J. T. Reid, J. K. Loosli, and K. L. Turk. Effects of preservatives upon red clover and grass forage ensiled without wilting. Part II. Feeding value. Cornell Agr. Expt. Sta. Bul. 913. 1955.

Cooperative Publication

The evaluation of forage crops varieties and strains for use and adaptation in the northeast. Project NE-10, Northeast Regional Publication No. 19. New Jersey Agr. Expt. Sta. Bul. 777. 1954.

